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# THE PAPUA AND NEW GUINEA AGRICULTURAL GAZETTE

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18 MAY 1954

DEPARTMENT
OF
AGRICULTURE, STOCK AND FISHERIES
PORT MORESBY.

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DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES.

PORT MORESBY.

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The following numbers of the "New Guinea Agricultural Gazette" have been issued:

Volume 1, Number 1.
Volume 2, Numbers 1, 2 and 3.
Volume 3, Numbers 1 and 2.
Volume 4, Numbers 1, 2, 3 and 4.
Volume 5, Numbers 1, 2 and 3.
Volume 6, Numbers 1, 2 and 3.
Volume 7, Numbers 1, 2, 3 and 4.

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## COMMUNICATIONS.

All communications should be addressed to the Editor, The Papua and New Guinea Agricultural Gazette, Department of Agriculture, Stock and Fisheries, Port Moresby.

## NOTICE.

This publication for the Papua and New Guinea Administration is sponsored by:

The Honourable, the Minister for Territories, Mr. Paul M. C. Hasluck, M.H.R., Canberra, A.C.T.
His Honour, the Administrator in this Territory, Brigadier D. M. Cleland, C.B.E.

## SUBSCRIPTION RATES.

The first year's issue of the Papua and New Guinea Agricultural Gazette, New Series, 1953/54, will be issued free of charge, and where possible, on a reciprocal basis, to recognised institutions dealing with agriculture and related subjects. The Director, Department of Forests, has promised to contribute articles regularly to this Journal.

The annual subscription, payable in advance, for further issues will be 1/6d. postage paid, for each issue; or 6/- per annum of four issues, published quarterly and commencing with the quarter July to October, 1953.

As previously, overseas publications are sought on an exchange basis, and such reciprocation would be welcomed. The New Guinea Agricultural Gazette, prior to the war, had practically world wide distribution and it is confidently expected that this circulation will be renewed as already a number of requests for subscriptions have been received from overseas.

It will be noted that the name of the Gazette has been changed. The Publication will follow the form of the pre-war New Guinea Agricultural Gazette, and will deal with recent advancement in tropical agriculture. Members of the public are invited to submit items of tropical and general interest to the agriculturalists in the Territory. Also articles from interested contributors outside the Territory will be appreciated. It is fully expected that this new publication will supply a much needed want as a local journal on tropical agriculture and the problems of the pastoral industry.

THE

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# EDITORIAL NOTES.

There have been many requests for republication of an Agricultural Gazette by Territorial residents and Plantation interests. It is gratifying to realise this can now eventuate.

It is with pleasure that this Agricultural Gazette, New Series, is presented.

The new issue will be Volume 8, No. 1, so that continuity with the old series of the New Guinea Agricultural Gazette is carried on.

The lapse of more than ten years to this issue since the publication of the previous Agricultural Gazette has been due to circumstances far outside the control of the Administration and the Director and Staff of this Department. Attempts have been made to meet the interim post-war need for publication of departmental information by reprints of articles for the public, whenever possible, and by publishing articles for local information on particular subjects.

The previous Director, Mr. G. H. Murray, was lost in Rabaul at the time of the Japanese invasion with many of his staff and that was a serious loss to the Territory. Only four members of the pre-war Department are still here in their official capacity. So in the special presentation of this issue special thought is given to past contributors.

It should be observed that in post-war years the name of the Department has been changed to Department of Agriculture, Stock and Fisheries.

# ORGANISATION AND STAFFING OF THE DEPARTMENT OF AGRICULTURE, STOCK AND FISHERIES.

The staff of the Department of Agriculture, Stock and Fisheries has increased from about 22 non-native employees, prewar, i.e., 1941-42, to approximately, 100 personnel with a cadre of establishment of 172 positions, listed in the new classification of staff. There is a reserve of positions for other, mainly professional, appointments required to a strength of more than 200, to meet the future departmental requirements of this large Territory. This present organisation includes 1,500 native personnel (approximately) with an establishment of more than 2,000.

The Department is divided into six main divisions, namely:

1. Administrative
2. Division of Agricultural Extension
3. Division of Animal Industry
4. Division of Plant Industry
5. Division of Production and Marketing
6. Division of Fisheries

In addition, there is a Chemical and Industrial Section.

Owing to expanding development to meet the needs of a new country and because of the scattered nature and difficulty of communications in the Territory, a regional Departmental organisation is now envisaged with three main regions involved, later to be separated into sub-regional organisations.

The main regions are:

1. Papua
2. Mainland of New Guinea
3. Bismark Archipelago and Solomon Islands (Bougainville and Buka Islands) of the Trust Territory of New Guinea.

The regions are to be further sub-divided on a physiographic and geographic basis, e.g., Central Highlands, Madang/Sepik Districts, Northern and Southern Papua, etc., etc.

The size of the Territory of Papua and New Guinea is 183,540 sq. miles or a total of 117,465,600 acres. The distribution of the areas is as follows:

Papuan Mainland: 87,786 sq. miles; Papuan Islands: 2,754 sq miles; Total: 90,540 sq. miles.

New Guinea Mainland: 69,700 sq. miles; New Guinea Islands: 23,300 sq. miles; Total: 93,000 sq. miles.

The scattered nature of the Islands is demonstrated by the fact that the sea areas covered is from the Equator to 12 degrees South Latitude, and from 142 degrees to 156 degrees Longitude.

Pre-war probably 30 per cent. to 40 per cent. of the total area of the Territory was not under full administration control owing to the rugged nature of the country and difficulties of communication. These are being overcome by air transport. The whole area of both Territories is rapidly being patrolled and permanent Administrative posts established. The native population is in the vicinity of about 1½ millions.

The Territory of Papua and New Guinea Department of Agriculture, Stock and Fisheries operates three main agricultural experimental stations, staffed by senior technical and auxiliary personnel.

The Lowlands Agricultural Experiment Station, Keravat, New Britain District; The Highlands Agricultural Experiment Station, Aiyura, Eastern Highlands District; The Lowlands Agricultural Experiment Station, Epo, Central District.

In addition there is the Plant Introduction and Quarantine Station at

Laloki, near Port Moresby, and minor experiment stations at Bubia, Morobe District, and Kapogere, Central District.

There are in addition agricultural officers and assistants of the Division of Agricultural Extension stationed in about half of the fifteen main administrative districts who operate altogether six district and sub-district agricultural stations. These stations mainly act as centres for extension and instruction in agriculture and stock raising. It is intended that this organisation will embrace all districts when suitable staff are available.

The Animal Industry Division operates five main Livestock Breeding Stations under both highlands and lowlands tropical conditions, where all types of livestock, including studs of five breeds of English and Asiatic cattle are kept. There are three subsidiary stations used mainly for livestock staging and quarantine.

The Division of Production and Marketing operates two commercial rubber plantations and a coconut plantation for purposes of studying marketing, cost of production, mechanisation and other problems and supplying bulk planting material.

The Division of Fisheries began work with a survey in the Naval owned vessel M.V. Fairwind. This was practically completed when this fine ship was tragically lost at sea with all personnel. This severe loss of experienced staff has greatly hampered the development of fisheries investigations and it is only now that steps are being taken to re-appoint staff.

The potentialities and resources of this relatively under-developed territory have not been surveyed, in any detail. For this reason much basic data is lacking, and the provision of a Commonwealth Scientific and Industrial Organisation Resources Survey Team has been arranged. A Soil Survey Section to work locally in liaison with the Resources Survey is now being organised within the Department of Agriculture, Stock and Fisheries. The development of local soil survey facilities, which are ultimately to be expanded into full land utilisation survey, has become necessary because this Department, once native rights have been decided, has proportionately the main responsibility of selecting and reporting on land suitable for settlement and determining best land usage patterns, rotations and economic areas. It must also assist other Departments to indicate native land requirements as a guide to land settlement authorities here. This work is co-ordinated with that of other interested Departments, such as Forestry; Lands, Mines and Surveys; and District Services and Native Affairs.

# VEGETATIVE PROPAGATION OF CACAO FROM GREEN-WOOD CUTTINGS AT THE LOWLAND AGRICULTURAL EXPERIMENT STATION, KERAVAT.

Edited. By R. J. HARRIS, Q.D.A.

The importance of vegetative propagation by green wood cuttings has been realised by the Officers of the Department for some considerable time although it was not until the latter portion of 1949 that detailed experimentation was undertaken in this particular field. Interest was centred upon applying already proven overseas techniques.

## Propagators.

When it was finally decided to undertake propagation trials in earnest, the first thing attempted was the construction of a propagator along the lines of the "I.C.T.A. Solar Propagator (8)".

Limited success was obtained by using the Solar Propagator. However, to simplify procedures it was decided, towards the latter portion of 1950, to attempt methods of propagation that would greatly reduce the costs of installing large cement and glass structures and obviate the necessity of having extensive water reticulation systems. This work was undertaken for several reasons, not the least important being the difficulty of obtaining suitable building materials from local sources and the fact that the average person on plantations would be able to construct the more simple propagators with materials already on hand. Materials such as packing cases and similar wooden structures, together with sheet glass coverings, were selected as the basis for experiments.

## Propagators of Simplified Type.

In the first trials ordinary Oregon Pine packing cases 25" x 15" x 14" deep, raised 3" from the ground on pieces of wood were utilised. Drainage was insured by means of holes bored in the base of the case, the base being lined with small stones on top of which was placed well rotted sawdust to a depth of 6-inches. The cacao cuttings were inserted in the prepared soil and the case covered with glass and cheese-cloth. The immediate success obtained in striking the cuttings prompted further experiments along these lines.

All further trials were laid down using home-made cases measuring 20" x 30" x 12" deep and using 6" x 1" timber for construction. It is considered quite practical to have larger cases constructed provided the glass used is of sufficient size to cover them without causing any appreciable drop in the internal humidity. The cases were so made as to be left with small openings between the narrow planks or slats forming their base so as to enable excess water to drain away. These slat type openings in the base were covered with small stones and over these stones well rotted sawdust was placed to a depth of 5". Cheese-cloth coverings were placed over the cases and on top of the cloth was placed sheets of one-eighth inch plate glass.

It will be seen that the cases so constructed were by no means elaborate and their assembly calls only for semi-skilled craftsmanship.

The disadvantages resulting from the fact that the life of the case so constructed is limited because it is made of wood and, due to continuous watering, is kept in a constantly wet condition, are offset by cheapness of construction. These factors would more than repay any expenses involved in replacement, even if its life is only 18 months. The life of any particular case, of course, depends on the type of timber used in its construction, e.g., whether hardwood or of softwood. In these experiments the painting of

the inside of the cases, either for preservative or light reflecting purposes, was intentionally avoided in order that costs might be kept to a minimum.

Cacao cuttings in place in the wooden boxes which are used as propagators.

The alternative cement propagator, covered overhead by bamboo slats and by glass and cheese cloth over the cuttings.

Cuttings set in place in the above propagator.

There is nothing against the use of a permanent cement structure for propagation of cacao cuttings; however, ease of portability is a decided advantage. Where it is desired to produce large quantities of cacao cuttings the obvious procedure is the arrangement of a number of boxes in "batteries," particularly as the boxes constructed as described above are light and thus capable of being easily transported to selected sites in the field near where planting is to be done.

## Selected Trees and Cuttings.

The cuttings are taken from the terminal green-wood, which has hardened following a "flush" to a stage where the leaves, when gently crushed in the hand, emit a crinkling sound, but do not crack or exhibit signs of damage. In the field the cuttings are generally taken longer than required. This is done to permit a further cutting immediately prior to insertion in the propagator. In this way a freshly cut surface is brought into contact with the rooting medium. It is sound practice not to remove all the green-wood of the parent tree but rather to leave a small proportion so that the natural development of the tree is not excessively hindered. However, the availability of suitable wood governs this factor. Where material permits, the longer and thicker the cutting, the better.

The cutting of material from the tree is usually performed early in the mornings. There have been various opinions expressed as to the best time for collection. Some authorities consider that it is advisable to collect in the late morning, by which time the terminal stem and leaves have had an opportunity to build up and store available carbohydrates. However, there is little to support that any one time in the morning is better than another under New Guinea conditions. Cuttings are generally gathered about 7.30 a.m. and inserted in the propagator by 10.00 a.m.

For general purposes, cuttings are taken with ordinary secateurs, marked

for identification with a metal tag and wrapped in previously wetted hessian type material. This latter provides sufficient protection until it is possible to get the cuttings to the site of the propagators.

Where cuttings are taken from a parent tree in an exposed position, considerable trouble has been experienced in rooting them. Material from trees receiving only 40 per cent. to 50 per cent. of the full light intensity, tends to give better root strike. It is sometimes necessary to collect material in a completely exposed position. In this case, cuttings taken from the branches protected by the tree itself develop roots better than those taken from fully exposed branches.

During the experiments, certain of the numbered selections set roots more easily and quickly than others. This can be partly explained by the above paragraph as the selected parent trees were situated in areas of varying shade intensity. However, there are apparently other factors also governing cutting development. Cuttings taken from certain selections have set root up to three weeks before those of other selections which have been given identical treatment. Such cases are, fortunately, rare and usually these cuttings, if left for a longer period in the propagators, will set roots as well as the earlier developing types. However, death occasionally results where cuttings are left for excessively long periods due to the exhaustion of the available food stored in them. Various techniques have been evolved whereby cuttings can be kept by treating them with carbohydrate, sucrose solutions. These techniques are outside the scope of this paper.

It has been recorded that rooting percentages vary with certain periods of the year. As yet no significant variation has been detected, though it is probable that at Keravat, root development will be uniform, as the rainfall is relatively evenly distributed throughout the year. Where there is any noticeable variation, it will more than likely by connected with rainfall: root development falling off where trees are experiencing dry conditions.

### Future Propagating Material.

To ensure future supplies of selected parent material, it is general practice to plant up a specially prepared retaining block. Such a block permits the cutting of propagating material without damaging trees required for production and also permits closer observation and control of the parent material.

The propagational block at Keravat is interlined with **Leucaena glauca**, which supplies the necessary shade, in rows nine feet apart. Between these rows, provision is made for planting the Cacao in holes four feet apart. Once the cuttings are planted, the shade is adjusted to produce maximum suitable greenwood. In this way, by careful pruning of shade and cacao, an abundance of propagation material is obtained. Shade should be somewhat heavier than for trees planted out in the field for, as stated above, better rooting has resulted from cuttings taken from trees under 40 per cent. of the external light intensity. There is apparently a correlation between shade and the flushing of cacao, and this must also be taken into account if the maximum propagating material is to be obtained.

### Site of Propagator.

The cases to be used as propagators are generally mounted in a site where natural shade is to be found, i.e., under a tree. If this is not available, then artificial shade will have to be created, either with calico, hessian, frond or lath constructions.

General view of the lath shelter in use at Keravat for establishing cacao cuttings.

Internal view of shelter showing the cuttings hardening in bamboo containers, the propagation boxes and the cement hardening chambers.

Light, and the rooting medium, together, form the most important factors for successful root formation and the resulting high percentages of root development.

Considerable trouble was experienced in the original work due to the neglect of the light factor and the placing of too much emphasis on temperature and humidity control. The first attempts resulted in complete leaf drop in four to six days. The only time that a noticeable improvement was obtained

was during a period of overcast days. Alteration of the shade, but apparently to the other extreme, again resulted in heavy losses and a low percentage rooting. This is quoted to illustrate the importance of obtaining a correct light balance.

From information obtained, there are many more cloudless days experienced in this locality than in certain portions of Trinidad and other sectors of the British West Indies and Central Americas. This requires an alteration of their recommended external shade controls to suit local conditions. It was not possible to obtain a correct light balance when using calico awnings.

We have found that boxes placed in a light intensity of about 40 to 50 candle-power per square foot have given best results. The light readings were obtained by means of an ordinary photographic exposure meter. The general trend of the reading was towards the 50-foot candles. Whatever the reading, and this is important, it should be the objective to maintain the light, under the shade canopy, as even as possible. Without the aid of an exposure meter, it is difficult to give any guide as to the correct light intensity, and it can only be found through trial and error.

### Operation of Propagator-

The medium used with greatest success for the rooting of Cacao was ordinary rotted sawdust, to which had been added a small amount, approximately half an ounce per two cubic feet, of Cuprox, a commercial powdered Bordeaux preparation. The Cuprox is added to control certain fungi that tend to develop in the sawdust but it is not very effective, unless it is in a fresh condition. The sawdust is used to produce three batches of cuttings, and then discarded. It is possible that the sawdust could be used for a longer period before becoming useless, due to either complete breakdown of structure, or fungal infection. However, the nearness of a sawmill has permitted the renewal of the sawdust in the cases at three-monthly intervals. The Cuprox is added every time a new batch of cuttings is to be propagated. By digging to the bottom of large stacks of sawdust, which can be found near most sawmills, it is generally possible to locate material at an ideal stage for propagation purposes.

Coir fibre, well rotted and finely ground, has made a suitable substitute for sawdust. This is considered a second preference, for it tends to hold to the roots and cause damage when removing cuttings from the bins.

Suitable sand has been difficult to obtain from local sources and results have been very poor whenever it has been used. It consists of too great a mixture of fine and coarse grains which pack excessively when watered. Sand is a recognised rooting medium, and there is no reason why it should not be used provided that it is the right type. Coarse sands, given sufficient water, are preferred by some nurserymen for propagation work. However, care has to be exercised when using such sands, for excessive aeration can take place resulting in excessively calloused cuttings with slow root development. This abnormality can sometimes be overcome by more frequent waterings, but on the other hand, it would be far more advantageous to locate a finer particled sand. A suitable medium should be capable of good drainage coupled with the ability to remain in a moist condition until the next application of water.

The case is filled to a depth of five inches with rooting medium. This is just sufficient to permit lengthy roots to develop without becoming twisted and damaged by growing to, and coming in contact with, the bottom of the case. If trouble is experienced in this respect, and this has not yet been the case at Keravat, it is obvious that the case must be made deeper. Seven

to eight inches is generally sufficient space between the glass and the top of the sawdust.

The cuttings having been brought from the field, are immediately prepared for insertion into the propagator. This entails taking as long a cutting as practicable, though space inside the propagation chamber does not permit the selection of cuttings in excess of seven inches overall length. Standard practice now is the normal three-leaf cutting, with about two inches being allowed for insertion into the sawdust. Some material when brought from the field is of such a length that two cuttings can be taken from the one piece of wood. The leaves are cut with a sharp knife or razor blade to about one-third of their natural length and the main stem is severed to expose a freshly cut surface. The actual site or angle of the cut matters very little, for rooting takes place satisfactorily whether cut at nodes or internodes. A sharp cutting instrument is essential to prevent excessive damage to the stem and leaf tissues.

The freshly exposed surface is immediately dipped into a hormone solution and placed into the rooting medium at about three to four-inch intervals on the square. The treated cuttings are then watered, a single layer of wetted cheese-cloth put over the glass lid, or alternatively, the glass lid placed on top of the cloth. The internal bin temperature is generally about 83 degrees F. during the hottest hours of the day, though Cacao is widely tolerant as regards temperatures. The extreme temperature recording with root development still taking place was 98 degrees F. In order to obtain maximum root formation, it should be the objective to keep the temperature as near as possible between 83 to 85 degrees F., for, if exposed to continuous high temperatures, root development is retarded. The humidity was maintained between 94 to 100 per cent. throughout the trials.

Numerous types and concentrations of hormones have been used, with varying degrees of success. It was originally intended that only compounds which could be obtained from a commercial firm in ready-made form would be tested, since laboratory facilities were limited, and it was desirable to keep costs as low as possible for intending small producers. Hormones are expensive, and as very dilute concentrations are used, purchasing costs of concentrated ingredients could become an important factor where it is not intended to plant or establish large numbers of cuttings.

Trials were laid out in the case, as already described under the heading "Propagators," treating each of 12 cuttings with the following:

(a) Indole butyric acid—2½mg. per 1 c.c. of 50 per cent. alcohol.
(b) Indole butyric acid/Indole acetic acid powder.
(c) Potassium Indole butyrate/Pot. Napthalene Acetate solution.
(d) Control.

**Table of Rooting Percentages at Completion of 28 Days.**

| Treatment | Average Length of Roots | Number of Roots in Cluster | Percentage Strike |
|---|---|---|---|
| I.B.A./I.A.A. Powder .. .. | 2—3 ins. | 3—5 | 25 |
| P.I.B./P.N.A. Solution .. .. | 3½—4 ins. | 6—11 | 100 |
| I.B.A. Solution .. .. .. | 2½—3 ins. | 3—5 | 60 |
| Control .. .. .. .. | — | — | — |

A one hundred per cent. strike was obtained from all inserted cuttings; cuttings treated with the Potassium Indole Butyrate/Potassium Napthalene Acetate solution were outstanding. At the end of 28 days, roots in clusters of 6 to 11 measured three and a half to four inches in length. The next in importance was the Indole Butyric Acid solution, though it was necessary to replace forty per cent. of those thus treated for a longer period to obtain

roots of satisfactory development. Although root formation did eventually occur with the others, they were far too slow.

**Cacao cuttings removed from sawdust after three and a half weeks.**

Utilising the information thus obtained, bulk trials were laid down, and every time, though root percentages were not always one hundred per cent., they never fell below seventy-five per cent. At this point it might be mentioned that trials laid in dull weather, with the weather lasting for any length of time, cause a marked detrimental effect on the rooting percentages. For quick root development, the P.I.B./P.N.A. solution is superior to anything of some fifteen preparations tested to date. The costs of large quantities of this preparation are rather expensive, but when calculated that each cutting tested costs approximately .1 of a penny, it is almost insignificant in comparison with the value of the resultant trees.

The cuttings are watered twice daily, 7 a.m. and 3.30 p.m., with an ordinary watering-can fitted with a very fine rose. A third watering at 11.30 a.m. is sometimes given during very hot weather. Care is taken to see that the cheese-cloth and glass is replaced following every watering. It has been found unnecessary to lift the glass to harden the cuttings, as is so important with certain other types of propagators. This is probably due to the fact that a certain amount of air gains access through the timber joints. The periodic removal of the glass coverings for watering would assist in removing excessive carbon dioxide that might have built up in the chamber.

The cheese-cloth rots rapidly and has to be replaced at three-monthly intervals. The cloth can be placed on top of the glass without any detrimental effects. This increases the life of the cloth. Precautions have to be taken to see that the cloth does not blow off the glass, exposing the cuttings to excessive light. Frosted or painted glass has been used, and has given satisfactory results. It is not recommended except where cloth is unavailable, for having the wetted material near the glass causes the internal bin temperature to be decreased by as much as 2 degrees F.

Within six days, the majority of those cuttings that are going to shed their leaves will have done so, and are removed from the boxes. A cutting without leaves, or portion of a leaf, is taking up valuable space, for replacements can be inserted. Leafless cuttings, though occasionally setting root within the chamber, generally die following potting, where the roots wither and rot. The remaining cuttings are left in place for approximately twenty-two days, by the end of which time they should be ready for removal and potting. Those that have not reached a satisfactory stage of development are left for a further period to permit roots to develop.

**Potting.**

Under local conditions, it has been necessary to utilise bamboo pots for the potting process. They are not the best type to pot, but they are satisfactory. The pots selected are the largest diameter possible, 4 to 5 inches, and about 10 inches in length. These are split lengthwise into two portions, and then re-fastened with a piece of wire. This reduces damage to the roots when the time comes to plant in the field. The wire is undone, instead of slashing the bamboo with a knife, and the two sections separate easily from the soil.

The potting mixture in use is equal parts of well decayed compost, top soil and well washed river sand. To this is added equal quantities of muriate of potash and sulphate of ammonia, two ounces per two cubic feet of mixture, a day or so prior to the actual potting.

When removing the cuttings, care is taken not to damage the roots whilst putting them into place in the tubes. In most cases a quantity of sawdust adheres to the roots and it is a sound practice to leave it intact. It is worth remembering that Cacao roots are quick of growth, tender, and very easily broken or damaged. Careless handling can result in a rooted cutting being rendered useless for potting.

**Hardening.**

The cuttings having been tubed are placed in a hardening chamber for approximately fourteen days. The Solar Propagator has been found ideal for the hardening process, for the potted cuttings can be easily placed in the chambers. The lid of the propagator is completely closed fór two days. The following three days the cover is lifted to a height of one and a half inches, and then to three inches for the remainder of their time in the hardening chamber. Waterings are given at daily intervals for the first five days, after which time the cuttings are watered only once prior to removal.

Hardening having been completed, the cuttings are stood out under a lath shade, or other suitable shade, with a light reading one-fifth to a quarter of the outside light intensity. They are left for approximately two months before being planted out in the field. To give an exact period for them to be left under this shade is difficult, and can only be gauged following the production of the first few batches. Some authorities consider it advisable to remove to the field as soon as possible, for they consider that plant foods available whilst tubed, are limited, and hinder rapid development. Others advise a lengthy period in the tubes to enable them to stand up to the conditions with which they will be faced when planted in the field. Occasional applications of sulphate of ammonia and muriate of potash benefit the tubed cuttings.

The hardening for plantation purposes should present no difficulties even without the Solar Propagator. It is to be remembered that a loss of up to seven per cent. is sometimes suffered during the hardening process,

with occasional losses being even higher. A hole two feet six inches by five feet can be dug to a depth of one foot in a well shaded site, preferably near the propagators. On top of this hole is built a framework of planking another foot above ground level, thus forming a large chamber. The bottom of the hole is filled with sand to provide material upon which to stand the bamboo pots and affording, at the same time, a certain amount of drainage. The

Cacao cuttings in one of the hardening chambers.

Cuttings hardening off prior to being transplanted out in the field.

Cacao cutting in bamboo pot at four months of age.

structure is completed by the addition of a framework, calico covered, and acting as a lid. The principals for hardening, as already discussed, are used in operating the structure. A commercial product which seems ideally suited is "Windolite," a wire reinforced transparent plastic material obtainable in rolls two feet six inches wide. The product appears to be an ideal substitute for the glass and calico used in covering the hardening chambers, or propagation boxes.

## Further Possible Experiments.

The field for further investigation is considerable. Not the least important is the application to local conditions of the single leaf cutting technique perfected by Professor Stahel (2). It is widely used overseas and it is possible that it could be used in conjunction with the propagation boxes described. However, as the entire leaf is left undamaged in this process, the boxes would possibly have to be made deeper to accommodate the extra leaf surface. The benefit to be gained from one bud, one plant, where limited propagational material is available is obvious.

Another rooting medium worthy of trial is exploded mica. This is distributed under the name of " Amicalite," and should it give the results with Cacao that is has with other plants, it will be a most satisfactory rooting medium.

Losses on planting in the field are often high. Mortality might be reduced by further experimenting with better pots, experimenting with potting mixtures, and extending the length of time the plants are left to harden.

The problems with vegetative propagation of Cacao do not terminate with what has been described or discussed in the above. It does, however, seem to have promise for the small planter, who is interested in the benefits to be gained from vegetative propagation and is not prepared to spend a lot of time and expense upon large structures. As many details as possible to assist in answering problems that will and might come to the fore, have

been given. There will be many others that will occur, but once overcome, the financial returns from the crops of resultant trees should more than repay the trouble taken and expenses incurred.

## Summary.


i. A method of cheap propagation of Cacao cuttings is described utilising ordinary packing cases, or alternatively, home-made timber boxes measuring 20" x 30" x 12".

ii. Collection of material from the field, benefits in care of selection of parent material, and the planting of selected material in "holding" blocks are discussed.

iii. Site of propagators and the importance of light intensities are stressed.

iv. Sawdust is described as being the most promising of the rooting media, with the hormone treatment being preferably Potassium Indole Butyrate/Potassium Napthalene Acetate solution for use with multiple leafed cuttings.

v. Potting and hardening techniques are discussed using bamboo pots, with the cuttings being hardened in special chambers for two weeks prior to being stood out under a lath structure for further development.


## Acknowledgement.

I wish to express my indebtedness to Mr. H. S. Darke, who has been most helpful in making available numerous hormone preparations.

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# RICE INDUSTRY — BRITISH GUIANA.

(These notes have been received from Mr. J. C. Lamrock, B.Sc. (Agr.), Agricultural Officer, who was selected for overseas post-graduate training at the Imperial College of Tropical Agriculture, Trinidad. Mr. Lamrock has selected as his special project, "The Effect of Various Cultivation Techniques on Representative Short Term Crops." He visited the Crown Colony of British Guiana as an external part of his course at the Imperial College).

By J. C. LAMROCK, B.Sc. (Agr.)

At present approximately 40,000 peasant farmers are engaged in the production of rice, farming approximately 90,000 acres by primitive methods. There is approximately one million acres of virgin land in the coastal area available for rice culture but due to the unit head productivity of the peasant and his present range of equipment the present area cannot expand though the land and market is available for extended increase for the industry. The increase will come about as soon as the industry can be mechanised. The main stumbling block to mechanisation is the lack of a rice variety suitable for mechanical harvesting.

The cultivation of rice in British Guiana began with the influx of East Indian labourers, who brought with them the rice seeds and varieties which make up the industry of today, under a system of indenture to sugar plantations. Whilst the majority of these workers, having completed their terms of indenture, continued in the employment of the sugar industry, many of them branched out on their own and commenced cultivating small areas of land under rice as their sole means of livelihood.

The peasant farmer individually is unable to process his rice due to the capital required for milling machinery and the time, etc., for finding the best market for his produce. Thus peasants sell their crops as unmilled rice generally. The marketing of rice in pre-1939 days was effected either through the millers, commercial concerns or private speculators.

The commercial community were not long in developing an export trade mainly within the British West Indies, and in 1938 some 34 such exporting agencies were in existence. With so many exporting agencies and with processing controlled by no less than 175 small and often poorly equipped private mills, it was very difficult to maintain uniformity in the quality of exports as each agent purchased rice from various areas in which the system of cultivation, the varieties and the milling differed.

Prior to 1939 rice from the Far East had a strong hold on the British West Indies market and the British Guiana export trade had to face a formidable competitor, especially in regard to price. Apart from this competition the local purchasing agents were continually under-selling each other in the West Indian market. Conditions, as a result, were almost chaotic and the hardships of the producers were increased by the uncertainty of the value of their produce from year to year.

When war was declared in 1939, the rice industry bore all the marks of lack of organisation, instability and uneconomic prices and Government wisely seized control under Defence Regulations in order to regularise the situation. One of the reasons for this action on the part of Government arose out of the experience during the 1914-1918 war, when speculators, in pursuit of immediate financial gain, ran the local market in short supply in order to export as much as they possibly could.

The regulations provided for the establishment of the British Guiana

Rice Marketing Board as a single-buying/single-selling organisation through which all rice produced in the Colony, save a specific quantity which each producer was allowed to retain for domestic consumption, was channelled for distribution on the local market and for export.

After the cessation of hostilities, Government, acting on a mandate given by representatives of rice producers, introduced legislature for the establishment of the Rice Marketing Board as a statutory body with powers similar to those granted under the Defence Regulations.

All paddy harvested throughout the coastland is normally disposed of in the following manner:

(a) Retained by the producer for seed.
(b) Sold to the stock feed market.
(c) Delivered to mills for milling into rice.

With respect to (b), the use of paddy in the animal industry is considered a proper use of this product and the Regulations do not provide for any control over paddy disposed of in this manner.

With respect to (c), as soon as paddy is delivered to a rice mill it falls under the control of the Board, and a careful check is kept of the movement of all stocks thereafter.

Paddy is parboiled and milled into rice which must be delivered to the Board at its main warehouse in Georgetown or at established receiving depots throughout the Colony. Upon its receipt at the Board's warehouse, the rice is weighed by licensed, sworn weighers, and it is on the basis of weights ascertained by these weighers that payment is finally made. A small quantity of rice is then bled from each bag of the consignment claimed by the producer to be of uniform quality and these samples are thoroughly mixed in order to obtain a composite sample of the entire consignment. The percentage of breakage of the rice is then ascertained by mechanical means and, after comparison with guide samples of the grading standards which are established annually, a grade is awarded. The producer is then paid on the basis of his weight and the grade awarded by the Board.

In the event of dissatisfaction on the part of the producer in respect of the grade, he has the right of appeal to a special committee set up for this purpose.

In order to provide against transportation delays, the Board issues, at its country depots, advance payments against consignments of rice in transit to the Board's warehouses.

Rice purchased from producers is bulk blended by mechanical means into particular grades required for distribution on the local market and for export. Local sales are effected in co-operation with the Transport and Harbours Department and there are twenty-seven established local sales depots throughout the 160 miles coastline, at which consumers may buy rice at uniform prices, freight charges being absorbed by the Board in order that retail prices might conform with the Price Control Regulations.

In 1946 agreements were concluded with the Governments of Trinidad, Barbados, the Leeward and Windward Islands, which provided for the full supply of the full requirements of rice to those islands for a period of five years at fixed prices, and for a further period of three years at prices to be negotiated at the end of the initial period.

In its functions as a marketing organisation, the Board operates along the lines of ordinary commercial enterprise and purchase prices are fixed in strict relation to the selling prices both locally and abroad, in order to ensure a relatively small surplus after defraying operating expenses.

The surplus funds so accumulated are held in reserve for the following purposes:

(a) To provide a Reserve in order to offset sudden fluctuation in export prices downwards.

(b) To finance schemes for the improvement and advancement of rice cultivation.

With reference to (b) the Board in 1943 sponsored a scheme whereby pure line seed paddy might be produced in bulk and distributed to farmers on a system of exchange or outright sale, in order to ensure the maintenance of the production of high quality rice and to promote a better quality in areas where the use of seed from crop to crop, over a long number of years, has resulted in deterioration.

Storage facilities offered by the mills being inadequate, the Board has constructed a number of bonds throughout the coastline which provide farmers with storage. The bonds also serve as distributing centres for pure line seed.

In addition, the Board decided to construct modern warehouses in Georgetown, specially designed to provide more economical handling facilities by the introduction of mechanical equipment. The construction of these new premises was completed in September, 1952.

A scheme was sponsored by the Board whereby farmers might require agricultural machinery on easy terms. The scheme embraced the importation by the Board of suitable equipment and the resale of same to producers under Hire Purchase Agreements. Under this scheme, 113 tractors, 148 ploughs, 103 harrows and 65 rice harvesters have been handed over to farmers.

In January, 1951, the Board embarked on a new phase of operations—on the packaging of high quality whole grain rice in attractively lithographed cardboard boxes, each containing 2½lb. of rice. This rice was released for the export trade only and results have, so far, been very gratifying. It is planned to expand this project as far as the availability of supplies will permit and incentives have been provided for encouraging the processing and production of the very high standard required.

**Mahaicony/Abary Rice Scheme.**

The scheme which was started in 1942 as a war measure in an attempt to fill the gap left in the supply of West Indian rice requirements by the fall of Burma, has developed into a large scale project in the commercial production of rice under conditions of mechanical cultivation. This scheme was at first Government sponsored and is now operated by private enterprise, viz., B.G. Rice Development Co. Ltd.

Due to the emergency conditions operating at its inception no experimental or pilot work was possible, with the result that it was found in the light of later experience that many of the more fundamental features of the lay-out were not only unsatisfactory but that they could not be easily changed. The geometrical lay-out of the scheme with no reference to the topography of the area and the dual purpose drainage and irrigation system are the most notable examples; in other words, all land to be placed under irrigation should be laid out on the contour where possible.

Besides the engineering and administrative problems posed by the erection and operation of the mill, a mass of agronomic and agricultural engineering problems have arisen and have had to be tackled. The technique

of underwater cultivation has had to be evolved in response to the exceedingly wet weather conditions prevailing in the Colony, there being, on the average, only forty (40) workable days per season for dry land cultivation of the seed bed and including sowing. The search for and study of machinery best suited to local conditions has just been started despite the fact that war-time allocations forced on the scheme a premature standardisation of equipment.

The absence of varieties suitable to mechanical reaping due to lodging and easy shattering of the varieties grown has resulted in a very serious drop seed problem which favours the spread of red rice. In the last two years the investigation and control of this problem and the question of the relatively low yields associated with mechanical conditions have been the main objects of the agronomic research carried out at the scheme under the full-time guidance of an officer of the Department of Agriculture. Average mechanical harvested yields are in the order of 5—7 cwt./acre. The average efficiency of mechanical harvesting is 40—60 per cent., i.e., approximately half the crop is lodged so bad that only 50 per cent. can be reaped by machine. Some very promising results along both lines of endeavour have been achieved although, in the case of drop seed control, any solution in the absence of suitable varieties for mechanical reaping can only be of a short term and palliative nature as reinfestation is a recurrent process.

An area of approximately 11,000 acres lying between the Mahaicony and Abary rivers have been impounded and this forms the main drainage and irrigation works. Of this area 5,000 acres are occupied by the scheme and the remainder by small holders who use part of their land for rice and part for cattle.

Irrigation water is led in from the Mahaicony and Abary rivers through a central canal running through the middle of the scheme to the Northern boundary canal. Two 80 ton-minute pumps situated at the South-western corner of the scheme on the Mahaicony can be used for either drainage or irrigation when required.

Drainage takes place through the same network of canals, the main gravity outlet being through the Northern sluices on the control canal to the sea. This system is unsatisfactory as proper water control cannot be maintained, especially in wet weather.

In addition to cultivating 4,300 acres on the scheme, agricultural machinery is made available for hire, primarily to farmers who supply paddy to the mill. Investigations have been going on for the past two years on the possibilities of a beef cattle-rice rotation. Results have not been promising, due to the cost of fence erection, Zebu blood being tolerant to any yet devised electrical fence, and the condition in which the cattle leave the ground—bog and wallow holes, etc.—requires extra work in relevelling for proper flood control of ensuing rice crops.

The existing equipment consists of:

75 Tractors (Case LA, McCormick W9 and WD9).
19 Three bottom mouldboard ploughs (Case, John Deere).
11 Four bottom mouldboard ploughs.
6 8½ft. one way disc ploughs.
11 6ft. one way disc ploughs.
10 Four furrow disc ploughs.
3 Six furrow disc ploughs.
40 Four gang disc harrows.

10 28 run seed drills.
10 24 run seed drills.
35 Tractor drawn all crop harvesters.
14 Self-propelled all crop harvesters.
18 Threshing machines.

The bulk of this equipment is U.S.A. manufactured and of various makes and models being brought together under the exigencies of war. This has led to the difficulty of not being able to standardise on any set line of plant.

At the same time some of the implements are unsuitable for the conditions. There is no counterpart present of the Australian "Sundercut" (plough-cultivator) which means that newly deep ploughed land has to be disc harrowed 4-5 times if a suitable seed bed is to be obtained. This working with disc harrows sends up the cost of production appreciably. Australian implements have been requisitioned for but manufacturers have been unable to supply due to home demands.

All of this machinery is maintained on the spot in a workshop equipped to handle major overhauls. The workshop also undertakes repair work for the agricultural machinery belonging to farmers in the neighbourhood. Part replacement, etc., is at present extremely difficult due to lack of dollar funds, and it is only possible to maintain approximately 40 tractors in operating condition though £10,000 worth of spares are kept in hand.

Another difficulty is the lack of skilled and efficient mechanics. These factors add appreciably to the cost of production due to working time lost and tied up equipment.

At the centre is a modern rice mill capable of producing five tons of cleaned rice per hour. The bulk of the equipment installed is of U.S.A. manufacture, and again the main difficulty is the obtaining of spares due to dollar shortage. Two new rice mills are to be built at Anna Regina and on the Corentyne Coast. These new mills are to be equipped with Robinson and Grantex machinery similar to that installed in the new Co-operative mill at Leeton, N.S.W. The equipment compares favourably with any on the world market from the cost and efficiency point of view.

The mill is installed to recover all the bran and polish with a minimum of loss and husk is conveyed to the boilers for use as a fuel. The paddy grown on the scheme is supplemented by paddy purchased from private farmers. The average price paid is penny half-penny per lb. All paddy reaped by combines must be dried before it is stored. This is at present mainly carried out by two artificial dryers though a certain amount is still done by the sun on a large concrete drying floor.

All the paddy handled by the mill is parboiled before it is milled. The process was adopted commercially because of trade requirements and legislation among the colonies and countries of the Caribbean area and at the same time from the milling angle—parboiling tends to harden the grain and make it less susceptible to breakage.

# AND NEW GUINEA.
# DISEASES OF COCONUTS (COCOS NUCIFERA) IN PAPUA

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## INTRODUCTION.

This article is intended to present a preliminary account of the important fungus and physiological diseases affecting the coconut palms in the Territory of Papua and New Guinea. Several investigations were made previously pre-war by officers of this Department when a suitable well-equipped laboratory (later destroyed during the war) was available. It is considered, however, that sufficient data and recorded observations, although incomplete, are on hand to be of sound practical value to the local coconut planters; these may prove of general interest to investigators and others interested in the coconut and copra industry. A good deal of the information presented has been gleaned from unpublished departmental reports. Further, a study of the literature available from other countries proves most illuminating when their findings are compared with what obtains on plantations in this Territory.

It is pointed out that, although the diseases here are associated with fungi, physiological causes and soil deficiencies have not been investigated to any great extent up to the present time. This work is gradually being expanded by the Department of Agriculture. The aggregate losses due to these causes may not be so noticeable as those due to insect pests, particularly the leaf-eating types, but their effects are always present. It is certain that the physiological effects due to soil deficiencies and such diseases as "lightning strike" causing "False bud-rot" are amongst the most serious conditions affecting coconut palms in this Territory. It is known that coconut palms with reduced vigour, due to any causes whatsoever, become more liable to fungus attack, hence soil condition, drainage, cultural conditions and general health of the palms are usually intimately associated. It must be remembered that injuries and wounds caused by insects often open the way for severe fungus infection thus aggravating any damage already done. Some diseases as yet unrecorded here are listed and described:

## LIST OF COCONUT DISEASES RECORDED IN THE TERRITORY OF PAPUA AND NEW GUINEA TO THE PRESENT TIME.

### Bud Rot.

Epidemic Bud-rot **(Phytopthora faberi)**.—Suspected and described by Bryce and others; in view of recent findings this is present but not widespread.
False Bud-rot.—Primarily due to lightning strike, or, in some cases, fire.
Sporadic Bud-rot.—Mainly due to injuries. Numerous cases recorded from all parts of New Guinea.
Tapering Steam (see below).—Leading to collapse of the cabbage.

### Root Rots.

**Fomes Lignosus** (probably East Indian type)—**Rigidoporus microporus.**
**Fomes lucidus—Ganoderma lucidum.**
Brown Root-rot—**Fomes noxious.**
**Rhizoctonia bataticola—Macrophomina phaseoli.**—So far seen only on other plants here; recorded on coconuts in other countries.

### Stem Diseases.

Stem Bleeding—Thielaviopsis **(Ceratostomella paradoxa).**—Often associated with Lightning Strike.
**Marasmius palmivorus, Polyporus spp.**

### Leaf Diseases.

Thread Blight—**Corticium penicillatum.**
Grey Blight—**Pestalozzia palmarum.**
Leaf Spotting.—Due to **Helminthosporium spp.** (probably **H. incurratum)** or an **Acrothecium.**
Sooty Mould—**Capnodium** or **Meliola spp.; Anthostoma Cocois** (recorded by Rechinger).
Silver Leaf.—Cause not known, thrips may assist, fungus present.
Leaf-droop.—Soil deficiency and various fungi.
Leaf-break.—Soil deficiency. **Botryo-diplodia Fusaria,** etc.
Tip-wither.—Probably similar to above; **Nectria** stage present.
Bittern Leaf—**Thielaviopsis spp.**

Leaf Blight—Bacterial.

### Diseases of the Nut.

Ring Disease—**Botryo-diplodia spp.** (identified by R. J. Noble).
Nut-fall.—Associated with environmental and soil conditions, insects and various fungi.

Leathery Copra.—Associated with soil deficiency.

### Physiological Disorders.

Chlorosis and Die-Back.—Due to soil exhaustion. Often leads to collapse of the cabbage.
Frond Choke.—Probably also hereditary. Believed that it may be due to soil disorders.
Drought Wilt.—Common in times of drought. Some forms of Tip Wither may belong to this category.
Obscure physiological disease in New Ireland, causing wilting of central fronds of young palms.

### Suspected Virus Diseases.

Head Droop (also known as Cabbage Droop, Corkscrew or Cabbaging).
Genital Abnormalities (possible Mutations and Strain Effect). Yellowing of the palms.—May be genetical, as well as due to disease.
Female Palms.—Male flowers suppressed; nuts often without embryos or with very little copra.
Particular palms produce soft copra, which will not cure; might be hereditary in some cases.
Branching and twin palms.
Leaf bases remaining attached to the palms, either on the whole or portion of the trunk.

### Some Serious Diseases Recorded Overseas But Not Here.

"Cadang Cadang."—Disease of coconuts in Philippines—suspected virus disease.
Red Ring Disease—Nematode **Patho-aphelenchus cocophilus** (Cobb).
Root Disease **Diaporthe perniciosa**—Marshall.
Bronze Leaf Wilt—Suspected physiological (or Virus) in West Indies.

### Bud-rot.

According to investigators, but-rot is generally regarded as a serious disease in most tropical countries. Ocfemia (48) states that bud-rot has been recorded in Portuguese East Africa, Ceylon, India, Malabar, Florida, U.S.A.,

Trinidad, Jamaica, British Guiana, The Philippine Islands and several other countries.

One of the first records of an epidemic disease of coconuts was from the West Indies in 1934. Heavy losses occurred in Jamaica from 1891 to 1910 and at about the same period in Trinidad.

In the Philippines the disease spread very rapidly and the coconut planters became alarmed because their plantations were threatened with destruction. Through the efforts of Dr. Copeland (24) in Laguna (1908) an act was passed requiring that all coconut trees infected with bud-rot be cut down and burned. The disease has been considered serious in the Territory of New Guinea and is the subject of legislation, hence it is believed worthy of detailed discussion.

Bud-rot was proclaimed under the "Plantation Diseases and Pests Ordinance of 1916" in the Laws of this Territory (33) as a disease subject to inspection by qualified officers of the Department of Agriculture. Remedial measures were laid down, and penalties provided for in case of non-compliance with the provisions of the Ordinance. In the Ordinance the indications of bud-rot were stated as follows:

"Withering and turning brown of the central shoot (which can then be easily pulled out by hand) followed (or occasionally preceded) by the decay of the other fronds, and a soft, vile, putrid, brown rot in the heart, followed by the whole top falling off, leaving only the bare trunk."

Approved combative measures cited were: Immediate felling, cutting up and burning of affected palms, together with spraying of all palms and ground within a radius of 150 feet with Bordeaux mixture.

It is now generally recognised that bud-rot may be due to a variety of causes, hence evidence of the power to infect is necessary to establish the existence of any specific bud disease in a particular country or locality. It also appears necessary to differentiate between the rotting of palm buds and true bud-rot diseases. As bud-rot may be brought about by so many causes it represents a condition resulting from a number of such causes rather than a specific disease.

There have been several individual records of bud-rotted palms occurring in this Territory, not including those now known to be associated with lightning-struck areas. The incidence of these bud-rotted palms led Dr. Bryce (13-18) (late Director of Agriculture in New Guinea) to suspect that true bud-rot was present in this Territory. So far as one can gather from the records, no actual fungi or bacteria which could be held responsible for the disease were isolated. He described the condition of bud-rot (13) in a departmental leaflet and mentioned that in New Guinea this disease had been reported from New Ireland, New Hanover and the Witu Islands, and was no doubt generally distributed in the Territory.

**Phytopthora faberi**, which several authors consider to be identical with **Phytopthora palmivora**, was described by the same author (17) as being present on cocoa here, causing purple canker and pod rot. This was significant, as bud-rot in India (19) Philippines (56) and other countries is usually attributed to the fungus **Phytopthora palmivora**. Thus it was legitimately considered that where Phytopthora was present on cocoa it would most likely be found on coconuts.

Ashby, S.S. (6) stated that, although the Phytopthora of pod-rot of cacao in the West Indies appear to be the same species as that on the coconut, it is not believed to be the same strain, since the form from the palm has not been found able to rot cacao pods.

**The Bud-rot Position in Other Countries.**

The position in New Guinea, however, is, in the author's opinion, analagous with what occurs in Malaya, where **Phytopthora spp.** (59-61-62) is found attacking many plants, but was seldom seen on coconuts. When it does occur under specific conditions it can be serious. As an illustration, Thomson, Malaya (78) inoculated 40 coconut palms just above the bud with different strains of Phytopthora isolated from coconut, cotton, rubber and cacao, but only one positive result was obtained with **Phytopthora palmivora** from a coconut derived from India. Dr. Muller(44) stated personally that bud-rot due to **Phytopthora faberi** was practically of no importance in Java or the Moluccas and that only a couple of cases of probable infection had been reported.

The present author has only in one area so far seen this fungus on coconuts here; one case of spear die-back of oil palms at Keravat was due to a fungus thought to be **Phytopthora spp.** as seen under the microscope.

Stockdale 1906(75) pointed out that a proportion of the bud-rot occurring in Trinidad was purely secondary in its nature, being a consequence of the failure of the palms brought about by so-called root disease. This was later proved to be red ring disease (46) due to infestation with a nematode worm.

Johnson 1912(37) came to the conclusion that **Bacillus coli** (Esch. Mig.) or an organism indistinguishable from it, was believed to be capable of causing rot of soft tissue of the coconut plant and perhaps responsible for coconut bud-rot in the Philippines. This was due to **Phytopthora faberi,** and that the bacterium coli was not the cause of epidemic diseases there. He found that infection could be obtained through the growing point with cultures of this bacteria, but only in the case of severe injury, or excessive dampness. Bryce 1924(13) stated that it was rather an open question as to whether **Bacillus coli** is in this instance more than secondary, i.e., follows the Phytopthora attack and completes the ruin of the palm.

Ashby 1924(4) expressed the opinion that there were two bud-rots in the West Indies, one fungoid caused by Phytopthora and one bacterial caused by a bacillus, probably a strain of **Bacillus coli,** but there is some doubt as to definite proof. (See also discussion by Elliott(27) ).

Tucker 1925(80) in Porto Rico isolated an organism resembling **B. coli** from diseased buds, but the results of his inoculations were negative. He reproduced the disease **Phytopthora faberi** with or without wounding.

Dr. Butler, Director of the Imperial Bureau of Mycology, at the Imperial Botanical Conference, July, 1924, (20) indicated that he was of the opinion that **Phytopthora palmivora** was the only vegetable parasitic organism which had been proved to cause the destructive bud-rot of palms and was capable of attacking perfectly healthy palms and inducing severe epidemics of disease.

Stapp 1928(73) stated that it remains to be determined whether coconut bud-rot is due to bacteria ofrungi or both. Alston 1924 and 1925(1) British Guiana, stated that a disease, which was responsible for the dying out of the coconut palm in certain localities, was falsely designated by the name bud-rot for the reason that the bud was, as a general rule, the last portion of the crown to become affected, whereas in true bud-rot a disease caused by a species of Phytopthora, the earliest and most characteristic symptom was infection of the bud followed by collapse of the whole central whorl. A similar condition called "bud-rot disease," practically identical with the above, was described from Trinidad.

At the Imperial Botanical Conference it was suggested that the term "coconut wilt" be applied to these occurrences. Briton Jones 1928(9) distinguishes two forms of the root disease of coconuts recorded by Stockdale (75) and Nowell (46-47) in Trinidad, which he named respectively "bronze

leaf wilt'' and ''yellow leaf'' or ''tapering stem wilt.'' The latter is distinguished by a yellow discolouration of the leaves progressing from the tip backwards while all the leaves, including the central ones, become dwarfed. The latter is a chronic malady and its history and effects have not yet been worked out; its described symptoms are very similar to those described by Park as caused in Ceylon by a root disease associated with **Macrophomina phaseoli**. The symptoms described also resemble the tapering stem and chlorosis which is believed to be due to soil deficiencies present in New Guinea.

Briton Jones, in his book ''Diseases of the Coconut Palm'' 1940(87) described the bud-rot complex and sub-divided the old term ''Bud-rot'' into the following separate diseases: ''Bronze Leaf Wilt.'' ''Phytopthora Bud-rot,'' ''Tapering Stemwilt'' or ''Pencil Point,'' ''Red Ring Disease,'' caused by **Aphelenchus cocophilus.**

The pre-war Director of Agriculture, Mr. G. H. Murray(45) who saw these occurrences in Trinidad, felt certain that the bronze wilt does not exist in Papua and New Guinea; and did not think that the tapering stem disease is the same as the one found in this country.

Smith, 1934(71) Jamaica, states that in Montego Bay area a form of bud-rot in which no fungal pathogens appear to be actively indicated has caused severe damage.

**Identification.**

The following description of bud-rot is collated from various publications. The first visible indications of the disease are the falling of the young nuts on the palm and the withering of the youngest leaf; there is no known way by which the earliest stage of the infection may be detected as, when the first visible symptom, or the browning of the young leaf, occurs, the growing point is already rotted. The young emerging leaf becomes yellowish brown or light brown and projects upwards sword-like from the crown. The leaf dies because the softer part of its base is completely rotted, and if pulled firmly can be drawn out from the crown or enclosing leaf sheath. At the base will be found a soft grey or brownish mass of rotting material which emits a vile smell. The stench is apparent on merely walking past a diseased palm. If the diseased palm is allowed to stand the youngest leaves become involved and soon die, the oldest leaves being the last to be affected, at which stage the bud or cabbage is completely decayed. The dead central leaf is often first broken by the wind (believed to be more typical in Phytopthora infection) and may fall to the ground. The older leaves may remain green and retain their usual position for several months, but as they die they are not replaced, and finally the trunk is left bare.

Only the soft parts are affected, the hard trunk and the roots remaining healthy, but once the bud is destroyed the whole palm of necessity dies. Often the young spathes are rotted in the same manner as the bud, and often the young racemes of flower heads will be found dead when the spathe opens. A close examination of these dead racemes will show that they are invaded by the fungus at their bases. Sometimes, but not in this case, rows of dark brown spots across the pinnae or leaflets may be seen, due to infection by Phytopthora.

Nowell 1921(46) described bacterial bud-rot and stated that this does not affect the central bud alone, but may commence anywhere in the crown, either at the base of the leaves or inflorescenses or on the tissues between them. It never extends far on the leaf stalk nor does it affect the woody part of the stem. Only in exceptional cases does it travel more than a foot or two into the softer central portion of the stem below the crown. It was pointed

out that typical bud-rot also follows rapidly on the death of healthy trees from poisoning or severance of the stems.

Sharples, Malaya 1924(59) at the Imperial Botanical Conference indicated that some factors associated with severe attacks of bud-rot in Malaya are injuries caused by Black Beetle **(Oryctes rhinoceros)** or Red Strip Weevil **(Ryncophorus schach)** and tidal floodings occurring in fields adjacent to rivers where sufficient protection had not been made to prevent the entry of water. According to reports submitted to the same conference (5-19-25-47-59) swampy conditions of the soil give rise to a condition which results in bud-rot. This has been found to be the case in New Britain. Droughts may give rise to a similar condition, as may ill-defined root troubles. It was also asserted by some that the planting of immature nuts may cause a kind of bud-rot.

Emphasis was placed on the fact that growers of coconuts must not rush to the conclusion that cases of bud-rot on their estates may be caused solely by parasitic organisms. Good cultivation, good drainage and satisfactory manuring are likely to result in a reduced number of cases of bud-rot in palms. Correct agricultural methods would result in smaller losses from pests and diseases, although some epidemics are bound to occur.

**Bud-rot in Fiji.**

Simmonds, in 1921 and 1922(63-64-65) describes an outbreak of bud-rot in Fiji which he considered to be true bud-rot, and as this is one of the South Sea Islands, it is of more than usual interest to New Guinea planters. He stated that the disease seems to have been present in Fiji for at least ten years, but did not cause much anxiety until the years mentioned, when a large number of palms were destroyed on account of it. The disease was almost confined to the wetter portions of the group, where it was commonly found on the back parts of the estates along the foothills. The central heart rotted, leaving the outer leaves and ring of nuts apparently healthy. A similar bud-rot outbreak occurred in Pondo, New Britain, in 1941.

When an affected palm was cut down and the outer leaves removed separately, a greenish brown or yellow spot was seen and this communicated with the central portion of the tree, the whole of which was found to be rotten and in a very foul-smelling condition.

The investigations largely dealt with an outbreak at Taviuni, from which Dr. Garment(32) conducted microscopical examinations of the diseased specimens. He found bacteria associated with each, but believed the occurrence to be secondary. In a culture of diseased tissue he found a fungus which appeared to resemble closely **Phytopthora palmivora.** The Imperial Bureau of Mycology, in reporting on a similar specimen, could only identify the fungus as an intrøcellular Phycomycete (fungus group) whose mycelial characters may be similar to Phytopthora as no fruiting bodies were present.

Both Simmonds (2-65) and their Inspector of Plantations commented that the older coconuts growing near the sea shore are attacked very slightly, but that the disease was most prevalent on young coconuts following a strip of land at the bases of the foothills. This was a region of continuous rainfall and frequently of poor drainage, thus the coconuts were growing under unfavourable soil and climatic conditions. This indicates a more potent cause of apparent bud-rotting, and it is believed by the present author that this is comparable with some of the areas seen in the heavier soils of New Ireland some distance from the Beach.

**Some Examples of Reported Bud-rot Infected Palms in New Guinea.**

In May, 1921, at Talasea, New Britain, a plantation inspector stated that he noticed six trees suffering from what he considered was bud-rot

although no microscopical examination was made, and that many more palms had been destroyed previously.

An inspector for the Expropriation Board, in September, 1921, sent in a specimen from New Ireland from a palm which had earlier been attacked by Rhinoceros beetle; this was not considered sufficient to destroy the palms, which undoubtedly died from cabbage rotting. Several palms were affected in the same way and were within a few yards of one another. The symptoms appeared to be the same as bud-rot except that the smell, although very pronounced and persistent, may not have been typical. (The author believes that this was probably a case of lightning strike).

It was also stated that, although palms with rotten cabbage had previously been observed, it was thought that most of the cases were caused by beetles entering the cabbage. The soft tissues had been exposed to infection from bacteria and other sources, which set up a rot.

Over 600 palms, most of which were destroyed, were reported to have been affected by beetles and red palm weevil on one plantation and a fair number of these showed rotting of the cabbage.

At Talasea in March, 1922, the District Officer cut down a two-year-old palm, because when standing near this palm a powerful and peculiar odour was plainly discernable. No trace of beetle or weevil was seen, although the heart leaf was obviously rotting and the outer leaves drying off. On being split open the kernel of the bowl and lower stem was filled with a creamy coloured, pulpy and rotten mass of semi-liquid consistency. From the outside the trunk or bowl appeared healthy in appearance and was not punctured. It appeared, however, that the disease did not develop from the cabbage. Newport (then Acting Director of Agriculture), in reporting on this occurrence said that the condition described is occasionally met with in this Archipelago. It may be a kind of bud-rot but does not tally exactly with the recognised bud-rot in other countries, where the older palms are usually attacked.

The characteristic smell of true bud-rot somewhat resembles bad eggs and bad onions, while the smell from this palm resembled the putrid decay of ordinary vegetable matter, together with the sour smell of fermentation. He believed the case to be a local bud-rot (herein classified as sporadic bud-rot) which is not infectious and could be due to accidental causes.

Some isolated cases of what appeared to be true bud-rot were recorded from Namatanai, New Ireland, in the same year. In December, 1924, a plantation inspector reported cases of what were believed to be bud-rot on two plantations in the Witu group and the symptoms were described as follows:

"The disease appears to be a form of bud-rot and the first noticeable sign of the disease on a palm is on the second or third line of fronds, where the tips of one or more fronds die back a distance of two or three feet and hang down (C.f. leaf break).

Running down the midrib of these affected fronds, a dry rot, brownish in colour, was noticed and this rot extended down the midrib a foot or eighteen inches past the point from which the tip is hanging. On one plantation, three palms, killed by this disease, were cut down and carefully examined. At the base of the cabbage a circular mass of cream coloured rotted tissue, about 6 inches in diameter, was found which, when cut open, gave off a very offensive smell. It was noticed particularly that only the terminal shoot and the surrounding undeveloped leaves were absolutely dead and dry, while the lower fronds still remained green. Extending down the trunk from the base of the cabbage a dry brown rot was found which, in one instance, extended to a distance of twelve feet, while the trunk below

this area was exceedingly dry. The roots appeared quite healthy and no traces of beetles were found. The whole area where these palms were discovered was isolated and kept under observation.

The Plantation Disease and Pest Inspector, from the Department of Agriculture, was then sent to Witu to describe the disease and reported as follows:

"The disease is similar to that which was seen on one plantation in the Bainings district of New Guinea in 1922. The first indication of the disease is odd fronds broken in the centre, otherwise the palm appears to be perfectly healthy; the central frond was found to be dead but still standing upright. The palm has a very sickly appearance, about half of the fronds being broken in the centre and the **whole cabbage leaning over**, becoming gradually worse until the whole of the cabbage collapses (C.f. head droop or lightning strike). The fronds have a dark brown colouring running through the central stem to the point of fracture. The centre of the cabbage is full of a creamy rot or substance which gives off an offensive odour. The rot can be traced down the centre of the trunk for from 6 feet to 9 feet and occasionally up to 12 feet from the cabbage. This rotted area takes the form of a funnel, tapering off from about 6 inches in diameter at the top to a very fine point as it travels down the stem. The trunk below this is practically devoid of sap and is very tough. Palms which are newly affected appear to be very dry when the stem is cut. The affected area is on low-lying ground about 20 feet above the sea—odd affected palms being located on swampy ground near the beach."

Bryce 1925(18) wrote regarding this disease at Witu Island and stated that from the description the disease is undoubtedly bud-rot. He also said that the danger of rapid spread of this disease is great and that preventative measures should be undertaken immediately and drastically applied. The diseased or dead palms should be cut out and burnt, particular attention being paid to the destruction of the bud and corm.

It should be noted that it is not clear from the records whether the terminal shoots died first, further that the occurrence was confined to particular areas. No causal organisms were seen and in view of recent findings it is likely that this was a case of Phytopthora Bud-rot. Nevertheless this conclusion must be open to doubt when expressed by one who did not investigate the occurrence. The macroscopic (visible) characters were suggestive of true bud-rot, though the fact that no further spread was reported seems to discount this possibility. According to the description it appears that some "Head Droop" may have been present, also the low-lying soil conditions described would have been unhealthy for palms. It is clear that such records of bud-rotted palms led to the conclusion that epidemic bud-rot was probably present in New Guinea. The bud-rot position here has been found to be exactly the same as described by Simmonds (Loc.cit.) in Fiji.

**Definition of the "Bud-rot" Problem.**

Sharples 1928(61) in defining the coconut disease position stated that up to 1918 the coconut disease position was largely influenced by the results published by Johnson(37) in his work relating to bud-rot. The uncritical acceptance of Johnson's inoculation results has led to much confusion as, according to Nowell(47) and Briton Jones (9) the technique of inoculation was faulty as the infection stands were made in holes 45 cms. deep bored into the tender tissues at the crown of young coconut palms grown under glass. Thus it is evident that not much else was needed to cause their death.

The results of Sharples' 1924(59) inoculation experiments proved that numerous widely separated organisms other than members of the genus Phytopthora were capable of producing typical "bud-rot" symptoms when stab-inoculated directly into the cabbage or bud, hence wound inoculation may be unsatisfactory in elucidating the causes of bud-rot.

It is evident from a study of the literature that the investigations on the bud-rot position have been very complex and difficult to follow even in other countries. It is thought essential that the true position regarding the occurrence of bud-rot in New Guinea be expressed.

Although suspected at various times, as far as is known few authentic occurrences of true infections of epidemic bud-rot have been recorded in Papua and New Guinea. It seems that the records from the Bainings and Witu Island were due to **Phytopthora species.** The coconut palms here which have been believed to be bud-rotted and recorded as such fall into five groups as far as can be determined.

1. Phytopthora bud-rot in scattered areas as described.
2. False bud-rot due to lightning strike or fires, which is described elsewhere.
3. Palms which suffer from tapering stem, presumably due to soil exhaustion, leading to eventual collapse and dying back of the cabbage. This may be associated with root disease but no proof seen. (See discussion on deficiency diseases).
4. Sporadic bud-rotted palms, where the disease is, in most cases, secondary to injury by animals such as rats, mechanical injury, insect injury, etc.
5. Maturation and mature palm wilt leading to bud-rot will be discussed elsewhere.

There have been isolated cases of bud-rot due to fungi or bacteria, but these are very scattered where present at all, and in 1940-41 fungi were isolated from bud-rotted tissues, from Pondo, New Britain. After a recent severe attack of **Promecotheca antiqua** on one plantation in New Britain, many palms withered up and lost their cabbage, leading to death of the palms. It has been demonstrated that when bacteria of the **Bacterium coli** group are introduced into very young buds through injuries or insect punctures, they can develop in the soft nutritive tissue and cause a destructive rot.

**Authenticated Case of True Phytopthora Bud-rot at Pondo, New Britain, in 1940.**

The late Director of Agriculture, Mr. G. H. Murray, and other departmental officers investigated and macroscopically diagnosed true "bud-rot" on crowns of palms from Pondo plantation, New Britain, in 1940.

Microscopic examinations of specimens of diseased tissue was made at the Imperial Mycological Institute which revealed the presence of fungus mycelium and this was considered to be Phytopthora from measurements taken. Further detailed microscopic examination was made by the author in the laboratory at Rabaul from fresh specimens. Large concentrations of unmistakable spores were found without any secondary infection. It was found definitely that the bud-rotting fungus **Phytopthora palmivora** was present. The best microscopic slides were obtained from a naturally isolated almost pure culture of the organism in the central tissue of the lower trunk (a most unusual site for this fungus to occur). The mature spores, "oospores," and resting spores were unmistakable under the microscope as they showed the varying forms and pronounced beaks characterising the spores of this fungus.

What was undoubtedly the same fungus was previously found associated

with a case of "Spear die back" of oil palms at Keravat Lowlands Experiment Station, but only a few oil palms were lost and the condition cleared up.

The bud-rot as described above developed under flat and foothill conditions in a region of heavy rainfall in an abnormal climatic season and even then only in such areas as where the palms were growing on heavy soil liable to water-logging. It was found also that near the focus of infection there was a central lagoon with some water lying around in the dry season but much more under wet conditions. A small river running near by also assisted in keeping up the humidity as did the fact that high tides and beach saltwater backed up the fresh sub-surface water almost to the foothills and created excess humidity both in the soil and in the atmosphere, making the conditions almost like a warm humid incubator. Obviously these are optimum conditions for the development of the bud-rot fungus, **Phytopthora palmivora**. It was ominous that severe wilting became apparent in most palms on the affected areas so that the presence of disease was obvious. The presence of nutfall was such that both large green coconuts and small nuts fell and littered the ground and later on the fronds commenced to wither and die and fall off. It was seen that other fungi such as Botryodiplodia were also thriving under these severe conditions and that the palms had lost their turgidity and become limp in appearance. There was some fear that the disease would spread to other properties but this proved unfounded and the indications were very strong that the disease would only prove serious under comparable soil, soil-water and climatic conditions to those indicated as the fungus can only develop in a moist or saturated atmosphere.

It is now certain that the fungus **Phytopthora palmivora** is widely spread in the Territory of Papua and New Guinea. It is noteworthy that there are other species of Phytopthora present in this country and their relationships need to be determined, e.g., **Phytopthora colocasiae** on taros. Apart from the coconut palm there are plenty of other host plants available (e.g. cacao **(Theobroma cacao)**; betel nut palm **(Areca catechu)**; oil palms, pawpaws, rubber **(Hevea brasiliensis)**; etc.) which plants this fungus is known to attack. It would appear, therefore, that it is only under certain special circumstances that this fungus is liable to cause serious losses of coconut palms and even then probably only when a virulent strain of the fungus is present.

Strong measures were then indicated and taken to control and confine this particular outbreak. Two men were employed in this disease control work and measures taken were to drain the area with the assistance of the owners and their native staff, making numerous drains of considerable depth. All infected palms were cut out, stacked and burnt, palms thought to be in the early stages of infection were painted with Bordeaux paste. Loss of palms spread over about twelve months and the disease was confined to the one property; somewhere around twelve hundred palms were cut down. In some instances they were in close contact and in others scattered. The infection rose as a curve, a few palms being noticed early and later many more became infected, but as draining and cutting out commenced to take effect the losses gradually reduced to nothing. It was found that the rainfall and the incidence of the bud-rot was very closely correlated.

### Soil Conditions Associated With Bud-rot and Their Relation to Other Diseases.

Association of unfavourable soil and climatic conditions with the development of true bud-rot, in which the fungus **Phytopthora Palmivora** (Butler) was in evidence, have been recorded from certain New Guinea plantations.

It is not intended that the sporadic occurrences of bud-rot be described in detail in this article. Certain contributory factors found in the situations where an outbreak occurred and which are of decided value in illustrating the conclusions of this present article are described. This is the first undeniable diagnosis of true Phytopthora bud-rot here and this was arrived at from investigations by the Director of the Department of a loss of several hundreds of palms. This fungus was at first definitely suspected from the macroscopic symptoms present (i.e., from the visible appearance and symptoms of the disease). This determination was backed up by the opinion of the Director of Imperial Mycological Institute, based on the presence of fungus mycelium closely resembling Phytopthora, and from the descriptions and specimens forwarded to him. Unmistakable spore forms of **Phytopthora palmivora** were later isolated in Rabaul, from the tissue of a diseased coconut palm.

The only losses of palms from bud-rot recorded here are from regions of heavy rainfall and usually occur under abnormal weather conditions. In the most recent records, it was noted that the first appearance of the disease coincided with a period when the rainfall was much wetter, in the wet season, and much drier, in the dry season, than was usual. This gives a much greater contrast of climatic conditions between the wet and the dry seasons (see graph). The loss of palms occurred on heavy soils under flat and foothill conditions. Significantly, it is under very similar circumstances that the scattered occurrences of bud-rot in Fiji have been recorded by Simmonds (87-88) and others.

The occurrences of this disease have been almost confined to the wetter portions of the Fiji group, being commonly found on the back portions of the estates, along the foothills. This comprises a region of continuous rainfall and frequently of poor drainage, where the coconuts grow under unfavourable soil and climatic conditions which favour fungus development, but reduce the vigour of the palms. Palms growing close to the seashore with optimum water-table conditions are affected slightly as was found in the occurrences here.

The environmental conditions prevailing where bud-rot has been recorded here have many features in common with those obtaining where the other diseased conditions, described in this article, have been recorded, but are more extreme.

The heavy soils present are liable to water-logging in the wet season, and to drying-out and compaction in the dry season. This tendency is increased in areas of heavy rainfall and where poor drainage exists.

In a typical soil-profile of an affected area, it is found that there are proportionately large areas with very compact, almost impermeable hard-pan, or clay layers, present, which hold the water at the surface and restrict root-growth. In certain flat areas, where loss of palms, frond-fall and nut-fall were most in evidence, a stiff clay band was present, usually at a depth of 6 inches to 9 inches, but often almost to the surface. It is seen from water lying about in shallow depressions and from other signs that a superimposed water-table exists in the wet season which disappears in the dry season. The evaporation of this surface water continually adds to the humidity of the surrounding atmosphere.

Below the first clay zone there was, in several places, a sandy sub-soil layer present which was loose and porous and extended to a depth of at least 2 feet. Below this again a second impervious clay band is often met with, which is blue-grey in colour (showing the presence of unoxidised iron) and represents a second zone where depositions of fine particles has taken place.

The root systems of coconut palms growing under these conditions are restricted by the relatively impervious layers near the surface, especially as the water stagnates there in the wet season.

Some root-growth does occur below the first clay layer, but is absolutely prevented where a second clay layer or other hard-pan exists.

In the dry season the loose sand, underneath the clay, is believed to reduce the water supply to the palms, which effect would be greatly increased in the dry season. The clay layers present hinder water movements and the access of the roots to the true water-table. It is obvious, without reference to the bud-rotting and other organisms present, that such conditions are not optimum for the growth of coconut palms, though they do favour most types of fungus development. The Phytopthora bud-rot disease particularly can only be exceedingly destructive in a very moist atmosphere.

Where bud-rotted palms are found on the sides of low foothills, the water-table may not be so close to the surfaces but the soil conditions may still lead to water-logging and restricted root-growth. On one typical area it was seen that the surface soil was a stiff chocolate clay loam, which was stiffer even than those soils found on the flats. The sub-soil was an extremely fine-grained and puggy clay, resting on a compacted layer of weathered parent basaltic rock. This weathered rock formation gradually merges into the unweathered parent rock at a comparatively shallow depth. The soil as described is very puggy in the wet season but sets like a brick in the dry season. Palms growing under these conditions do not flourish. This can be seen from the chlorotic leaves, reduced length and number of fronds, and the grass ground covers present showing a light overhead canopy. It is impossible to think that such climatic conditions and soil and water-table formations, do not have a great deal to do with the development of bud-rot. Obviously, it is no coincidence that the type of bud-rot found here, and in Fiji, occurs under such conditions.

In the Philippine Islands bud-rot only assumes epidemic proportions in one of the most humid districts of the islands, where the soils are heavy and wet.

The late Dr. Sharples(59) in 1924 enumerated several instances of where investigators had recorded outbreaks of bud-rot in various parts of the world which were associated with unfavourable soil and climatic conditions. It was resolved at the Imperial Botanical Conference of 1924(59) that the term "coconut wilt" be applied to such occurrences as were falsely designated bud-rot, for the reason that the bud, as a general rule, was the last portion of the crown to become affected.

It is the author's opinion that, whether the crown is affected first (as in the instances of true bud-rot given) or last, the soil conditions always warrant very close study wherever outbreaks of wilts and bud-rot occur.

It will be mentioned right throughout this article that there are several other diseases and conditions of the palm influenced by related environmental conditions. In this regard it is a significant fact that on some areas where true bud-rot was recorded here, the following series of diseases or symptoms were noted: Leaf-droop, leaf-break, nut-fall (bad), frond fall (bad), leaf scorch, deficiency spotting, taper stem, chlorosis, stem bleeding, **Pestalozzia**, leaf-spotting, thread-blight **(Corticium penicillatum)**, **Botryo-diplodia theobromae** and a condition tentatively named "gummy leaf." It is plain that many of these conditions (especially the first nine listed) are symptomatic of the particular soil conditions prevailing, rather than distinctive diseases.

It is worthy of note that Dynastid beetles (e.g., Rhinoceros beetle **(Oryctes rhinoceros** and **O. curculionidae**; Red Palm beetle **(Rhyncophorus**

**ferrugineus; Xylotrupes gideon)** had caused considerable damage under these conditions and probably favoured the spread of the disease.

There may be a number of inter-related and inter-acting factors (working both from within and outside the palm) responsible for palms showing a series of pathological derangements such as those described.

It is very clear from the considerations outlined that cultural practices designed to keep up the vigour of the palms and remedy unfavourable environmental circumstances are of the utmost importance in disease control.

This subject will be expanded under separate headings in future contributions of this article.

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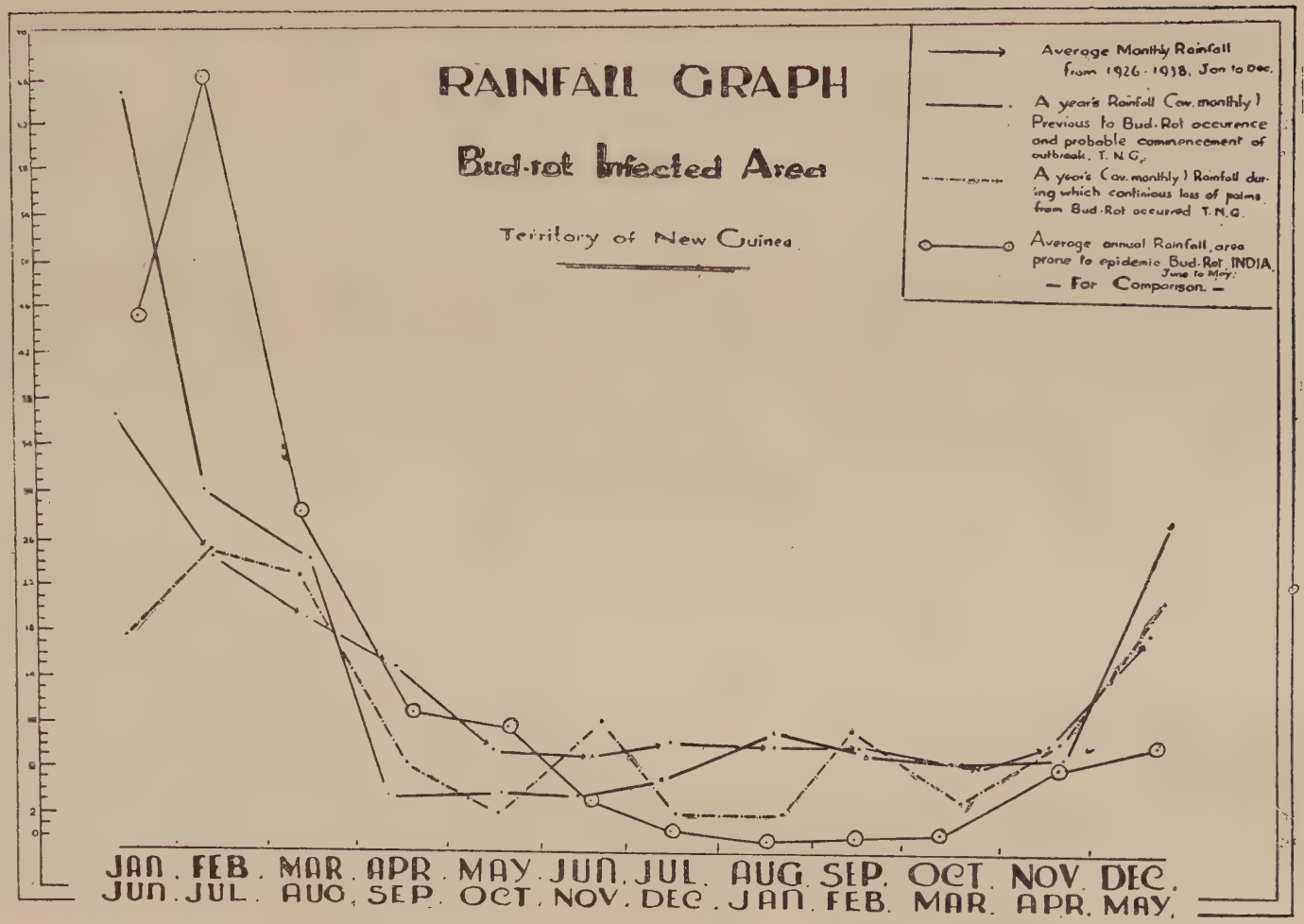
RAINFALL GRAPH
Bud-rot Infected Area
Territory of New Guinea.
Average Monthly Rainfall from 1926-1938. Jan to Dec.
A year's Rainfall Cav. monthly) Previous to Bud-Rot occurence and probable commencement of outbreak. T. N. G.
A year's Cav. monthly) Rainfall during which continious loss of palms from Bud-Rot occurred T. N. G.
Average annual Rainfall area prone to epidemic Bud-Rot. INDIA. June to May.
— For Comparison. —
JAN. FEB. MAR. APR. MAY. JUN. JUL. AUG. SEP. OCT. NOV. DEC.
JUN. JUL. AUG. SEP. OCT. NOV. DEC. JAN. FEB. MAR. APR. MAY.

# GRAZING INDUSTRY — PAPUA AND NEW GUINEA.

(Following is the text of a statement released by the Department of Territories in mid 1952).

## Introduction.

The extensive grasslands of Papua and New Guinea offer great scope for the development of a grazing industry. There are areas in both Territories which are eminently suited to sheep and cattle raising. Though there were about 27,000 head of cattle in the Territory before the war, there were few, if any, sheep. Cattle in the Territory now number about 5,000 head and sheep about 1,600 head. Although only a few ventures in cattle raising on a comparatively small scale have so far been undertaken in Papua and New Guinea there do not appear to be any insuperable obstacles to the expansion of the grazing industry.

About 2.8 million lbs. of fresh meat and 6·4 million lbs. of preserved meat are imported annually into Papua and New Guinea. Production of meat in the Territory could aim at least at the present levels of imports of about 10 million lbs. per annum. The Government will do everything possible to encourage the expansion of the grazing industry in the Territory to at least this level and will provide technical services.

## Sheep.

Most of the sheep now in the Territory are Romney Marsh sheep located at Nondugl in the Highlands of New Guinea. This breed has been tried in various parts of the Territory. It produces a good carcase and, in drier parts, a useful fleece. There are also some Asiatic sheep and, crossed with Romney Marsh, they produce good carcases and are hardy. Current investigations on sheep raising include tests and observations to determine the most suitable breeds and areas for grazing for both mutton and wool.

## Cattle.

A number of British breeds of cattle are represented in Territory herds. For dairying, Jersey and Australian Illawarra Shorthorns are most popular, while Black Poll, Polled and horned Shorthorns are represented for meat production. These breeds have done well in the Territory under good management. Arrangements are in course for the introduction of Zebu breeding stock to provide the basis of experiments in conjunction with C.S. and I.R.O. into the possibility of developing, by crossing British and Zebu blood, a breed which will combine the good beef producing qualities of British breeds with the hardiness of Zebu cattle. Such a breed would be eminently suited to conditions in Papua and New Guinea.

## Methods of Stock Management.

Specialist opinion favours the view that for a number of reasons the Territory lends itself to cattle raising by farm methods in preference to "open range" holdings. The main reasons for this view are:

(a) Large tracts of land with good communications are not generally available;

(b) Cattle, particularly those of the Zebu strain, are more easily marketed in prime and fat condition if raised under farm methods;

(c) In most of the potential grazing areas there is adequate rainfall to permit heavier carrying and better pasture management than is practical in such areas as the Northern Territory;

(d) Since the importation of foundation stock is relatively expensive, it would probably be uneconomic not to give them the care associated

with intensive rather than extensive management, particularly in the matter of disease control.

Nevertheless, there are areas of grassland, for instance, in the Central District of Papua and the Sepik District of New Guinea, where open range grazing might be undertaken, though it seems that even there, in the long run, there would develop a trend from open range management towards stock farming.

**Carrying Capacity of Land.**

Under intensive management, including fodder production and control of internal parasites, probably one beast to the acre could be carried in many parts of the Territory.

**Diseases.**

The livestock of the Territory are, even by standards in Australia, remarkably free from serious disease. None of the serious diseases of Asia, such as foot and mouth disease and rinderpest, are present—nor is contagious bovine pleuropneumonia. Anthrax is endemic in the highlands, but is easily controlled by use of vaccine manufactured in Australia. It is expected within a few years the Territory will be free from cattle tick, and even now it is practicable to eradicate tick on a herd basis and to keep new herds free from infestation. Buffalo fly are present, but are not a great source of trouble. There is a bad screw-worm fly in parts which is troublesome to wounds and the navels of calves. Conditions favour development of internal parasites in parts of the Territory; in areas which have a definite dry season they are likely to be of least consequence. If care is taken at importation, the building of contagious abortion-free and tuberculosis-free herds is quite practicable, and an aspect of great economic value.

**Water.**

Even in areas where there is a long dry season, usually permanent surface water is available. Generally speaking, it is not difficult to obtain sufficient head of water for the operation of hydraulic rams. There is scope for development of hydro-electric power.

**Types of Feed—Grasses, Edible Shrubs and Trees.**

The grasslands of the Territory apparently are artificial products of the native method of hunting which involves burning whenever there is a dry season.

In lowland areas and on the lower slopes the dominant association of these grasslands is a mixture containing **Imperata cylindrica** (the grass known in Malaya as "Lalang," in the Philippines as "Cogon," and in New Guinea as "Kunai" or "Kurra Kurra"), **Coelorrachis rotboellioides**, and **Saccharum spontaneum**, the dominance of any one of the three varying with local environmental variations. Though palatable immediately after cutting and burning, this type of sward is a very fibrous and poor feed. On light sandy soils and well-drained slope areas **Themeda australis** dominates, and provides open range type grazing but such a sward has a low carrying capacity and poor resistance to intensive use.

On level land at 5,000 feet altitude and above **Themeda gigantea** dominates. This is fibrous and of poor value. With judiciously controlled burning and some preliminary weeding, a palatable and nutritious sward of native fine grasses, principally **Poa spp.**, **Sorghum nitidum**, and **Apluda mutica** can be induced. These grasses are very sparse in the original sward.

In country with rainfall above 100 inches and a poorly marked dry season, clearing gives a sward of soft grasses in which **Paspalum spp.** (particularly **P. conjugatum**) predominates. Although this sward gives a fine bulk of palatable green feed, it is nutritionally inadequate without a legume

or cereal supplement. A number of useful legumes which have been introduced as plantation cover crops are available to introduce to this type of sward, notably **Pueraria spp.**, and **Centrosema spp.** Valuable introduced grasses thrive under these conditions; for example, Para grass **(Brachiarya mutica)**, which is outstanding. **Paspalum scrobiculatum, Axonopus compresus**, and **Digitaria spp.** Among cultivated fodders for these conditions Pigeon Pea or Dahl **(Cajanus indicus)**, grain and Sweet Sorghums, Sugar Cane, Cowpea **(Vigna catjang)**, and Peanuts **(Arachis hypogea)** are outstanding; maize tends to be subject to excessive insect damage. Supplementary feeding and foraging with root and vine crops such as Sweet Potato **(Ipomoea batatas)**, Tapioca **(Manihot esculenta)**, Pumpkins and melons **(Cucurbitaceae)**, Mauritius bean **(Stizolobium spp.)** and Kangu **(Ipomea aquatica)** is readily available.

In areas with a more marked dry season, Guinea grass **(Panicum maximum)**, Elephant or Napier grass **(Pennisetum pupureum)**, and **Stylosanthes spp.** are most useful introduced fodders; certain potential fodders such as **Leucaena glauca**, the rain tree **(Pithecolobium saman)** and Algoroba (**Prosopis juliflora)** can be readily grown. There is a need for storable cereals and pulses in such areas and Maize, Grain Sorghum, Peanuts and Pigeon Pea are of importance.

At higher altitudes certain temperate and sub-tropical grasses and pasture legumes can be established. Notable among these are:

Grasses: Perennial Rye **(Lolium perenne)**, **Phalaris tuberosa**, **Paspalum dilatatum**, and Rhodes Grass **(Chloris gayana)**, with Kikuya **(Pennisetum clandestinum)** giving good grazing cover on hungrier soils.

Legumes: White Dutch **(Trifolium repens)**, Alsike **(T. hybridum)** and Red **(T. pratense)** clovers; **Lotus spp.**, which seem to be better adapted to the rather generally acid soil conditions; and Lucerne **(Medicago sativa)** which is limited rather strictly by soil pH.

An important recent introduction which shows promise under a wide range of ecological conditions is Berseem or Egyptian clover **(Trifolium alexandrinum)**.

Generally the Territory must develop pasture types and grazing and feeding patterns following more closely those of tropical countries than those of Australia.

# EXTRACT FROM A REPORT ON A VISIT TO THE TERRITORY OF PAPUA AND NEW GUINEA TO STUDY AND ADVISE ON TEA GROWING IN THE TERRITORY.

By Dr. J. G. CHURCHWARD, B.Sc.(Agr.), Ph. D.

## Areas Suitable for Growing Tea.

Tea will grow under a wide range of soil and climatic conditions. Its best development, however, is limited by the interaction of several factors which go to make up these conditions.

Tea will grow on most soils, but will do best on those which are well supplied with the essential plant nutrients. More important, perhaps, than the nutrition status, is the physical condition of the soil. It should be porous, well-drained, but not one which dries out readily. Nevertheless, good tea gardens are known which are situated on fairly heavy clay soils as well as on old lateritic soils.

The optimum pH. value for tea soils lies at about 5.5—otherwise soils with a lower value (more acid) should be chosen.

Tea will grow from sea-level upwards in the tropics provided that soil and climatic conditions do not act as limiting factors.

The disadvantages of growing tea at low levels are associated usually with the poor physical (and sometimes chemical) condition of the soils which are often non-porous heavy soils, subject to white ant invasion and with difficulties associated with shade. Moreover, the quality of the prepared tea is usually poor. (It is true that fair quality teas are manufactured from gardens in Assam which are situated at heights of 300 ft. or less above sea level, but the latitude of these areas should be kept in mind). It is generally conceded that the greater the altitude the better the quality of the prepared tea. The two chief factors which set the upper limits where tea can be grown are temperature and sunshine.

In countries with a latitude similar to that of Papua and New Guinea heavy losses may occur because of frost, especially in recently pruned gardens. (Here again it should be noted that any damage to tea bushes due to frost in Assam cannot be compared with that which may occur on similar material grown in Java at certain altitudes. At latitudes of 7 degrees-8 degrees, where the cambium of the tea bush stems is more or less always active the plant is not in a physiological condition to withstand frosts).

At higher altitudes, with the lower soil and atmospheric temperatures the growth and development of the tea bush is slower and smaller crops are obtained. This is associated not only with temperature but with the lack of sunshine, especially during the wet season. In parts of Java in certain periods of the year there are only 2 or 3 hours of sunshine during the day.

In general, it may be said that it is not an economic proposition to grow tea below 750 ft., a better proposition at 1,500 ft., and the optimum commences at about 2,500 ft.

The question of altitude is probably one of temperature and there is much to be learned in this field. It is known that the optimum surface-soil temperature lies between 25 degrees—35 degrees C.

Air temperatures, per se, have little significance; the temperature—moisture relationship is of importance. Excessive evaporation or transpiration should be avoided. In this connection, winds, especially hot winds, are unfavourable for the best development of the tea bush.

The rainfall requirements for tea are variable but, in general, lie between 100 inches and 200 inches per annum. The quantity of "effective" precipitation is determined by the distribution of the rainfall, soil moisture-holding capacity, evaporation, etc. Lower rainfalls evenly distributed throughout the year may be as effective as higher total annual precipitations in areas with a distinct dry season.

In areas where the rainfall is low at any time during the year, soil moisture plays an important role. (Hence the need for ground cover and shade). In areas with high precipitation, evaporation is not so important.

One author has given the following classification according to the amount of rainfall:

(a) Dry months—where less than 2.5 inches of rainfall per month.
(b) Medium-dry months—where 2·5 inches to 4 inches of rainfall per month.
(c) Wet months—where rainfall is greater than 4 inches per month.

A good general rule to follow in selecting an area for growing economic crops of tea, as regards rainfall, is that it should not normally be subject to more than 3 to 4 "dry" months.

There are considerable areas in the various districts which were visited which measured up well to the requirements set out above. There is little doubt that many of the areas referred to will produce 600lbs. of prepared tea per acre per annum, some areas probably very much higher yields.

In the following notes, which concern areas in the Territory best suited for tea, it should be remembered that the inspection of the several districts was somewhat superficial. It is suggested that a more detailed survey be made by officers of the departments concerned to determine the actual areas which measure up to the requirements set out above. In doing so, it is suggested that the start should be made in the most likely areas which are mentioned below.

It should be emphasised here that in considering suitable areas for tea, regard was paid only to whether the tea bushes would produce sufficient crop, which, under conditions prevailing elsewhere, would be considered economic. No account has been taken of accessibility to market, labour supply, etc.

The soils in the areas which were visited can be classified roughly into two large groups with a number of variations within each group.

A. Soils derived from old metamorphic rocks, chiefly schists and gneisses. These soils are to be found around Garaina and the area extended westward from Aiyura as far as the Baiyer River Valley.

These soils are medium to good in fertility depending on the conditions under which they have developed. Most profiles show a top horizon about 12 inches to 18 inches in thickness of black soil apparently rich in organic matter. There is a sharp line of demarcation between this and the underlying clay.

This clay is often mixed with parental rock material sometimes in the form of impervious gravel layers in the old high river terraces. Laterisation seems to be proceeding in these soils. Such terraces are to be found in the Goroka Valley and part of the Waghi Valley. With proper treatment, these soils should be suitable for growing tea.

A similar type of soil is found on the foothills in most of the valleys but these are less fertile due chiefly to native cultivation. The clay is very much stiffer than that on the high terraces and when super-saturated with moisture causes serious hillside slipping. This is not considered suitable soil for growing tea.

The low-lying soils on the valley bottoms with heavy blue clays developed under anaerobic conditions are also considered unsuitable for

tea, in their present condition.

All of these soils respond to good cultural methods. If drained and conditions made possible for the development of the microbiologic population in the soil, tea should grow well on them. There is one such valley-bottom lying between foothills to the south of Aiyura (in the direction of the Kuminakara fields) which shows promise. It is suggested that 200 acres of this area be drained and planted with tea for observation. The area, after draining, should be planted with a legume, possibly Crotolaria, which should be ploughed in. It is anticipated that the development of the tea bush may be comparatively slow in the first two years but more rapid later on in this area.

In addition to the above mentioned soils, there are others in which the metamorphic material has been mixed with granodioritic material from volcanic intrusions. Such soils are to be found around Aiyura, Garaina and possibly Karanka. Any other similar areas should be regarded as good prospects for tea growing.

B. Soils derived from volcanic material, such as those of the Sangara lands which have probably developed from trachytic-andesitic material. Similar soils are to be found in the Mt. Victory region, and probably at the Western end of the Waghi Valley around Mt. Hagen. These should prove first-class propositions for the cultivation of tea.

To summarise; if reconnaissance surveys are to be made the best prospects seem to lie in the following areas, which are expressed in order of preference.

1. Areas where the soils are derived from trachytic-andesitic material in the Sangara, Mt. Victory and Mt. Hagen areas.
2. The lateral valleys leading into the Baiyer River Valley.
3. Areas where the grano-dioritic material from volcanic intrusions has been mixed with the schists and gneisses such as are found at Aiyura and Garaina.
4. High river terraces, especially where leading up to the mountains as found in the Goroka and upper Waghi Valleys.

## Entomological Notes.

# PLANTATION HYGIENE AND RHINOCEROS BEETLE (ORYCTES RHINOCEROS).

(Following is an extract from some notes written by the Government Entomologist, Mr. G. S. DUN, B.Sc.Agr., on "Plantation Hygiene and Rhinoceros Beetles").

In the past few decades a good deal of attention has been paid to evolving practical measures whereby the damage the pest does can be reduced to a minimum. In no case have any outstandingly successful results been achieved. Nevertheless, various procedures can be adopted which, if carried out thoroughly and continuously, will tend to reduce the incidence of beetle attack, particularly in the case of heavy and localised outbreaks.

It has been mentioned before that the damage to the palms is caused solely by the adult beetles. The larvae normally live and develop in palms only after they have been killed. Generally speaking, it can be assumed that eggs will be deposited and larvae develop in any medium which contains a reasonable amount of rotting vegetable material. This covers such a wide range of materials that it would be an evident impossibility to check the beetle entirely by eliminating all the available breeding grounds. There are, however, a number of obvious sites which should be removed, destroyed or avoided as a matter of standard plantation practice, since these provide foci from which concentrated attacks on nearby palms will develop. Certainly the adoption of all or some of the methods mentioned below have achieved an appreciable measure of success in countries where they have been carried out.

From observations which have been made locally in recent months, and from overseas experience, it is possible to list a number of media which are extensively used by beetles for egg-laying. These include—

1. Dying and dead coconut and other palms. These appear to be the most favoured breeding medium in the Territory. Virtually all dead palms harbour the beetle larvae at some stage of their decomposition whether they are left standing in the plantation or are used for building purposes.
2. Town or village refuse heaps.
3. Vegetable rubbish (Cacao pods, coffee pulp and husks, leaves, garden compost pits, rotting fruit, etc.)
4. Waste material from sawmills.
5. Rice husks.
6. Banana stools.
7. Decaying logs in recently cleared land or normal forest detritus on plantations which adjoin cleared land,

and many other media of vegetable origin. It is worth noting here that coconut husks do not appear to harbour the beetle larvae. It is advisable, nevertheless, to ensure that the husks are spread in an even layer rather than allowed to accumulate in heaps. By so doing, the possibility of encouraging a concentration of soil of high humus content below the pile is avoided.

It has been observed that any vegetable material that is allowed to accumulate is not immediately suitable for the beetle to breed in. The optimum stage of attractiveness is only reached some three months after it has been put down and the attractiveness remains only for 9 months to one year, by

which time full decomposition has normally been completed. This time factor then will allow vegetable accumulations to be disposed of over a considerable period, thus avoiding any marked disruption of normal plantation routine.

Another favoured breeding site, which, however, is at present of limited importance in the Territory, is on plantations where stock is run. Cattle sheds, night paddocks, manure pits, etc., will always develop a heavy infestation of Rhinoceros beetles in their immediate vicinity unless the dung is regularly turned and the grubs destroyed or it is treated with some soil insecticide like Clordane.

The treatment of the breeding sites, while not always a simple matter, is nevertheless strongly recommended as the only method available of lessening the severe local concentrations of the pest which are developing at a number of points in the affected parts of the Territory. Brief notes are given below on some ways of disposing of the main breeding sites.

**(a) Dead or Dying Palms.**

Every effort should be made to remove these continuously as a standard plantation practice. They appear to be the most favoured breeding sites available and each one is capable of supporting as many as 100 or more full-grown larvae. It is preferable to cut the palm out slightly below ground level. It is a standard practice in Samoa to cut them out at waist level and gouge out the cut surface so that it collects rain water and so becomes unsuitable as a breeding medium. This method is not advocated in the Territory as the moist stump appears to be a suitable breeding ground for the various species of Palm Weevils which invade any cut or damaged palm surfaces. Disposal of the trunk is necessarily rather laborious but it is useless to cut it down unless it is effectively disposed of. In areas where trenches, foxholes, etc., still abound, the trunk may be cut into suitable lengths and placed in these, provided always that the topmost layer is covered with at least 8 inches of humus-free soil (clay, sand or subsoil). Such a layer will effectively disguise any vegetable matter from adults seeking sites for egg-laying.

Disposal of the trunks by burning is often impracticable, particularly in areas of high rainfall. Under dry conditions they can be effectively burnt if care is given to stacking the cut and split lengths, making sure that sufficient air spaces are left to allow development of an adequate draught.

If the labour is available the trunks should be cut into 3-4 lengths and then split into four. If these sections are stacked so that only two lengths are in contact with the ground and the remainder criss-crossed above them, they will dry out too rapidly for them to become suitable breeding sites. (As these dry, a proportion of the lengths can be used as fuel for the copra drier). As a general practice the use of sound coconut trunks for constructional work such as bridges, driers, labour houses, etc., is not to be recommended. If there is no alternative, care should be taken to see that the cortex is removed and the trunk and both ends are treated with Creosote. Even then the posts should not be allowed to remain in use for a period longer than nine months. They should then be removed, destroyed and replaced with fresh ones.

**(b) Refuse Heaps.**

Town and village refuse heaps are not only excellent breeding grounds but are undesirable from a public health point of view. If at all possible, such rubbish should be incinerated. This operation should be complete or the unburnt residue will only form a further breeding centre.

**(c) Vegetable Rubbish.**

With the interplanting of Coconuts with Cacao, a standard practice in the Territory, the burial of broken pods beneath a layer of humus-free soil

becomes essential. The same applies, although to a lesser extent, to such items as Coffee pulp and husks, garden rubbish, etc., or some similar deterrent.

**(d) Refuse from Sawmills.**

These constitute a purely local problem as the mills usually are away from any concentration of coconuts. However, sawdust accumulations in town areas (e.g. Rabaul) could be equally as important a source of infestation as refuse heaps.

**(e) Rice Huskings.**

Again, such breeding sites are of little current importance in the Territory, but they are mentioned as a possible future breeding ground and as an example of the type of material which one can expect to become of importance at a later date. The same would apply to accumulations of detritus from fibre crops, such as Manila hemp, kenaf, etc.

**(f) Banana Stools.**

With its particularly vigorous growth locally, the Banana constitutes a two-fold attraction to the Rhinoceros Beetle. The adults feed rather readily in the growing plant, while the rapid breakdown of the plant after fruiting renders the ground in the immediate vicinity of the rotting stump a suitable site for egg-laying. Accordingly all available steps should be taken to eradicate bananas other than those in cultivation for food purposes.

**(g) Forest Refuse.**

This is a constant source of infestation about which little direct action can be taken. It is noticeable that heavy infestation often occurs on the edges of plantations which abut on uncleaned forest or recently felled bush. It is obvious that little can be done to avoid this source of infestation. The only palliative that can be suggested for this is the use of split coconut traps placed at intervals along the edge of the forested area. These can be made of 4-ft. lengths of coconut, split in half and laid in small groups with the split face to the ground. However, it is pointless using such traps if labour is not available to inspect them regularly and bring in the catch for destruction. The period between collections should be about six weeks but, if this is not possible, the inspections should not be left for a period greater than three months or they will defeat their object by becoming a breeding ground themselves.

The foregoing remarks have largely been confined to limiting the larval stage of the post. The adult is a rather more difficult stage to deal with and only two procedures can be advocated, viz., trapping and the examination of palms.

**(a) Traps.**

The usual larval trap of split lengths of coconut logs can be used against the adults as well as the larvae by instituting more frequent inspections. If this is done at fortnightly intervals a much larger proportion of adults will be caught.

**(b) Light Traps.**

This method has frequently been advocated but there is little evidence to show that it would be of any appreciable value on plantations. The adults have only a limited flight range (several hundred yards) and it would require a very powerful light to attract even the beetle population within a circle of this radius.

**(c) Examination of Palms.**

Under present day conditions, it is probable that this method would not be an economic procedure, except, perhaps for young palms between the ages of one to three years, when the major damage appears to take place. If a system

of examination is instituted it is quite essential to see that the entrance holes are blocked up whether they have been found to contain an adult or not. The adults return to freshly-made holes and will only be prevented from so doing by blocking them with some inert material such as clayey subsoil, a mixture of clay and kiln ashes, etc.

### (d) Collection of Adults.

The regular collection of adults among young palms was a rather regular practice in the Territory before the war, even before the entry of the Asiatic Rhinoceos beetle. With the advent of the latter, it is evident that the need for the collection of the adults is more urgent now. With regard to collecting, it should be pointed out that the beetles it is desired to catch are the two Rhinoceros Beetles, not the Elephant Beetle. The latter is a relatively unimportant pest of coconut but, being more accessible than its more important relatives, has a tendency to predominate in the daily catch. When caught, both larvae and adults make suitable fowl or pig food. However, it is as well to kill them prior to feeding them to stock as they will bury themselves rapidly in any loose soil they encounter and so escape before being eaten.

Unfortunately, no one of the palliatives which have been outlined above can be put forward as a certain cure for the Rhinoceros Beetle problem, particularly under present day conditions. However, by a judicious use of some or all of the methods, it should be possible to obviate the more severe effects which the beetle is capable of causing.

In conclusion, some mention should be made of a rather contentious point that is often raised, viz., the role of native plantings in fostering the Beetle and causing added infestation to plantations. The writer is inclined to think that their importance is greatly exaggerated. While it is not uncommon to see badly damaged village and self-sown palms, it is considered that, in effect, the general level of damage is less than on plantations where the palms are grown as a monoculture. It has been mentioned before that the adult beetle has a relatively limited flight range, a fact that would aid its increase on a plantation, and, at the same time, hinder its spread among scattered native plantings. Another point which is often overlooked is the importance of the village pig as a scavenger; it is probably the only effective predator operating in the Territory at the present time, and it is surprising the variety of situations from which it is capable of ousting the Rhinoceros Beetle larvae.

## Animal Husbandry Notes.

# COPRA AS A STOCK FOOD.

The methods used in the processing of green copra are not standardised and therefore the composition of the finished product is variable. However, an average composition on a dry basis is as follows:

| | Per cent. | Per cent. |
|---|---|---|
| Fat-Oil .. .. .. .. .. | 60 — | 70 |
| Water .. .. .. .. .. | 6 — | 10 |
| Protein .. .. .. .. .. | 5 — | 7 |
| Carbohydrate ash and fibre .. | | 15 |

Associated with the high fat content is a correspondingly high energy value, giving copra a food value (on an energy basis) twice as great as the food value of maize.

The water content of the copra is important because on it depends the quality of the processed product. The green copra may be dried by one of three methods, hot air, sun or smoke, but whichever is used, it is desirable that the water content is reduced to about 5 per cent., otherwise fungal growth and subsequent breakdown of fats to fatty-acids give rise to rancidity.

Free fatty-acids may also reduce the value of copra as a food by acting as pro-oxidants, thereby bringing about the oxidative inactivation and destruction of Vitamins A and D.

Finally, fatty-acids, if present in large quantities, may form insoluble calcium soaps which are assimilated with difficulty.

The protein content of the food is comparatively low and this should always be remembered when feeding copra to live-stock, particularly to sheep and cattle. Moderate amounts of copra with high fat content fed to stock in the presence of small amounts of protein and carbohydrate may create metabolic disturbances resulting in ketosis.

It is recommended to grind before feeding out, but this is often impracticable owing to the high fat content. However, by mixing the copra with a cereal such as Sorghum in the proportions 25 per cent. copra to 75 per cent. grain, the grinding is facilitated and ketosis avoided.

### Copra as a Food for Pigs.

Pigs become sleek and lively if fed on copra but if fed in excess they may be sickened by the fat. Pigs have been known to eat as much as 2lbs. of copra per day, but this is considered too much, 1lb. for a pig exceeding 100lbs. body weight and ½lb. for a pig less than 100lbs., being more desirable.

Young pigs may not take to the copra immediately but this can be overcome by introducing a little into the ration long before it is really required, say at the litter stage.

In the case of both young and old pigs, the copra can be fed either soaked in water or directly from the bag. Whichever is used it is desirable to add about ½lb. of a protein-rich food such as meatmeal.

### Influence of Copra on Carcase Quality.

There is a general fear that copra will taint bacon and give the fat a tendency to rancidity, but the properties of coconut oil are such that on fundamental grounds one would not expect these things to happen. So far, the reports on cured bacon are satisfactory, the fat is white, harder than usual, and free from any taint. However, for the present, it is advised that copra be fed to young and growing pigs and the grain which would have been used, fed to the finishing pigs.

# "FORESTRY": ADDRESS BY DIRECTOR OF FORESTS.

(At a recent meeting of the E.S.T.I.S. Committee at Tewantin, Queensland, Australia, the Director of Forests, Mr. J. B. McADAM, Dip.For., delivered the following address).

It may be asked why, if so much forest is available in the Territories, it is not made available more rapidly. One of the major reasons is that the bulk of the lands of the Territory are native owned and before they can be alienated and dealt with they must be acquired by the Administration. The legislation provides that if the native owners are willing to sell, the Administrator may acquire lands or timber rights. Ownership investigations are very carefully carried out, and if, as is usually the case in forest land acquisitions, the area is large, many natives may be involved and negotiations may be protracted. It is important to keep the confidence of the native peoples and to proceed at their tempo. They realise that development is to their own betterment in the long run and that the Administration is guarding their interests and an amicable agreement is the rule when the position is carefully explained to them. It is a condition of all such purchases that the District Officer responsible for the purchase must ascertain that it is not detrimental to the natives' interest before he may proceed with the purchase.

I am convinced that, provided access is developed sufficiently rapidly, the forests of the Territory are sufficient to allow a cut of several hundred million feet per year.

Ultimately, with the development of the standard of living of the local peoples, they themselves will have a demand of the magnitude of several hundred million feet per year.

For example, the population is now as great as that of Queensland, which annually requires between 300 and 400 million super feet of log for production of sawn timber. It will be many years before the local people develop such a demand, but even now their demand is gaining momentum. In the meantime, export market would provide a means of employment for many of them and as long as adequate measures of representation are applied there need be no fear for their future requirements.

A recent survey showed that Australia is at present importing the equivalent of 50 million super feet of logs worth about £200,000 of a kind similar to those available in New Guinea. With Australian enterprise those requirements might well be supplied from Australia's own Territories—Papua and New Guinea.

The Administration does not expect startling increases but it does look forward to a steady displacement of other suppliers by enterprise in the Territories.

This is looking only at the present position with a population of 8,000,000 people. Australia requires about 1,200 million super feet of sawn timber and falls short of her requirement by some 2 to 300 million super feet which she has to import. If the population reaches double present figures in the next 20 years as is the plan, this deficit may reach nearer a 1,000 super feet of timber per year.

That void will cause increasing prices and should prove a "Price to get supply" for many of the Forests of New Guinea which to-day, because of poor access, heavy shipping freights, poor equipment and inefficient labour, must be regarded as of negative royalty value.

Twenty years ago, the "secondary timbers" of North Queensland were not saleable. Twenty years from now the "Secondary Woods" of New Guinea

will probably be as sought after as the Crows Foot Elm, Sassafras and Qandong is at the present day.

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## Rural Broadcasts.

(The following is the first of a series of radio talks prepared by the Department of Agriculture, Stock and Fisheries and currently being broadcast fortnightly by Station 9 PA, Port Moresby).

## GENERAL REVIEW OF AGRICULTURE IN THE TERRITORY.

Agriculture is of the greatest significance in the economy of this Territory. The known population is at present about 1,300,000, of whom only about 1 per cent. are non-indigenous. Of this 1 per cent. about 30 per cent. are engaged in Agriculture. Of the natives, some 50,000 are engaged as employees in agriculture on the plantations, mining, commerce or by the Administration. For almost the whole of the remainder, agriculture is the principal economic activity, their labours being devoted to the production of food and small quantities of fibres, stimulants, tobacco, etc., in their village gardens and tree groves. When it is realised that the village populations are the source of labour for all organised commercial production in the Territory, the true significance of agriculture in the economy can be appreciated. From the knowledge we have gained from studying some commodities to date, it is estimated that a total of more than 1,000 tons of food per day is produced by native gardening methods throughout the Territory. Agricultural industries also lead the field in export production, agricultural exports in 1952-53 realising £6,196,350 out of a total export value of £8,199,583.

As would be expected in a country which has such great variation in altitude, the climate is far from uniform. In coastal regions, with the exception of an area 60 miles each side of Port Moresby, the rainfall is between 80 and 250 inches per annum with a consistently high range of temperature. The climate of the Highlands is cool and sub-tropical and there is only a slight variation in the mean temperature throughout the year. Conditions at both high and low levels vary from uniformly moist to a sharply defined dry season.. With this in mind, it is easy to appreciate the great diversity in agriculture found in this country and the manifold possibilities for development. The existence of a wide range of soil types, including considerable areas of rich volcanics and alluvials adds to these possibilities.

The general aims for food and export crops in the Territory are:

1. Improvement in native food crops.
2. The expansion of pre-war industries where practicable.
3. The reduction of food imports and improvement in native nutrition.
4. Development of new agricultural and pastoral industries.
5. The conduct of agricultural research and investigations essential for the wellbeing of existing rural industries and the development of new ones.

Although literally hundreds of species of economic plants are cultivated by native farmers for food, fibres, stimulants and similar purposes, only a few, namely, yams, sweet potatoes, taro, bananas and coconuts ever figure as major food crops. The important root crop staples offer considerable scope for improvements by selection and distribution of high-yielding and rapidly maturing varieties and by the introduction of improved types from overseas. The increase in the cultivation of certain food crops such as maize, peanuts, sorghum and fruits is expected to considerably improve the native food position and the Department of Agriculture constantly distributes seed of these and urges their greater use.

The efficiency of native agricultural methods in which the standard practice is to crop an area once or twice and then leave it to recover its fertility for a long period in natural fallow could be considerably increased. This matter is receiving attention by Extension officers of the Department of Agriculture and already some improvements have been achieved in particular areas.

The agricultural industries producing export commodities which were well established prior to World War II were Copper, Rubber, Cocoa and Coffee production. All suffered serious direct or consequential damage during the period of military activity and occupation here. The Copra industry has for many years been the mainstay of our agricultural export income and is still pre-eminent, 76,900 tons valued at £4,548,000 representing 65 per cent. of the total value of agricultural exports leaving the country in 1952-53.

Rehabilitation of planted areas of coconuts has progressed steadily since the war and it is noteworthy that native producers show an increased interest in this crop, the amount attributed to them in 1953-54 being 19,000 tons. New plantings of coconuts have been relatively limited and this is a cause of some concern as many of the best established areas are now of considerable age and showing signs of imminent decline. Desiccated coconut and coir fibre are important products associated with the copra industry. The Department of Agriculture has commenced and will continue with a programme of selection of desirable types of parent trees so that improved planting material might ultimately be distributed to persons wishing to replant or make new plantations but this is a long range project. The collection which had been built up at Keravat Experimental Station was unfortunately destroyed during the Japanese occupation.

Rubber, produced almost solely in Papua, is the second most important export, and since the war annual exports have risen from 1,000 tons to 2,800 tons. The Commonwealth Government has stated its support for the expansion of this industry and experts, the most important of whom is Mr. C. E. T. Mann, Director of the Rubber Research Institute of Malaya, have been consulted and given the opportunity of visiting the Territory. By the efforts of the Department of Agriculture in close consultation with men such as these, greatly improved rubber budwood and clonal seed of the newer high yielding strains is being introduced. A number of plantations are at present extending their planted areas and it is intended that introductions shall be continued so that all who are making new plantings can use good quality high-yielding material.

Of the export commodities at present produced here Cocoa undoubtedly seems at the present time to have one of the brightest futures and has been subject to very rapid expansion in the post-war years. Exports have risen from 15 tons in 1946-47 to 478 tons in 1951-52. The volcanic and rich alluvial soil types in this Territory are particularly suited to this crop. Native growers are showing an intense interest and it is estimated that they alone now have about half a million trees planted. The Department of Agriculture

has a well developed selection and breeding programme going at the Lowlands Experimental Station at Keravat, the aim being to provide high-yielding, good quality planting material, and this work has been stated to be pre-eminent by such well-known experts as Mr. D. H. Urquhart, formerly Director of Agriculture in Nigeria, who visited the Territory under the auspices of Cadburys Ltd.

Past experience has shown that both the Highlands or Arabica and the Lowlands or Robusta types of coffee can be grown well in the Territory and good quality coffee produced. Both European and native producers have shown considerable interest in coffee production in recent years, the former particularly tending towards Highland coffee, of which a number of plantations are now established at Wau and in the Central Highlands. Prior to the Mount Lamington eruption the largest producer in the Territory was the Sangara Native Coffee project. However, production here has almost completely ceased. It can be seen, then, that an increase in exports from 7 tons in 1946-1947 to 38 tons in 1951-52 almost entirely reflects the newer developments in the Highlands area.

When it is realised that the imports of the Territory of foodstuffs for the last financial year included as major items, food of animal origin valued at £1,821,066; 12,190 tons of rice valued at £960,969; 8,374 tons of grain and pulses valued at £383,933, it can be seen that the replacement of these items by locally produced foodstuffs is of the utmost importance in balancing the economy of the Territory and such a replacement is a leading objective of the Administration.

A chain of livestock breeding stations is being established and livestock are imported both for the Administration and for private owners. Special quarantine arrangements have been made to facilitate the import of stock from Australia and numbers of producers have been flying in young stock. About 26,000 cattle were carried on plantations before the war but very few of these remained at the cessation of hostilities. Pig production, both commercial and subsistence, is also being studied and encouraged with a view to reducing food imports. Pasture and fodder development, an almost untouched field in this territory, must not be overlooked as an important factor in production of meat and allied foods.

Rice is undoubtedly the most important of the foods at present being imported which could be produced locally and the Administration, through the Department of Agriculture, is making every effort to stimulate small farm production by natives and to develop suitable methods of mechanised production for European enterprise. A very considerable amount of progress has been made in both these fields of work and several European growers and large numbers of natives are now engaged in rice production. However, total production in the Territory at present would not exceed 1,500 tons annually, so that there is great scope for further expansion.

Other grains and pulses which can be grown in the Territory and would greatly relieve the food crop situation are maize, peanuts, soya beans, pigeon pea and sorghum.

With regard to new industries, and particularly new export industries, the Department of Agriculture has tested a number of crops which it considers suitable for development in this Territory. Of these the most important are Tea, Oil Palm, Kapok, Tobacco, Kenaf, Peanuts, Castor Bean, Manila Hemp and Sisal. Others such as Cotton will be the subject of tests yet to be undertaken.

The Department regards its function in relation to these as being to provide disease-free seed or planting material of the best possible varieties to meet local conditions and to test the economics of production so that

potential growers can be advised whether the industries are likely to be profitable or not in territorial conditions. On the other hand, where private interests feel sufficiently assured that they will invest capital and undertake developmental work with any particular crop, the Department will give them all possible material and technical assistance.

Research and investigation are of prime importance in any programme of agricultural development and to meet this need the Dejartment of Agriculture in the Territory has Experiment Stations at Keravat which is a Lowlands Station, Aiyura in the Eastern Highlands at 5,500 feet, Epo in the Western Papuan Lowlands which is particularly for rice work, and Bubia in the Markham Valley. Supplementary and demonstration work is to be carried out at the District Agricultural Stations which will eventually be established in all major districts. Animal breeding and research are being carried out at Stations in the Central Division of Papua, the Central Highlands region and Morobe and New Britain Districts, and it is hoped to extend this work to the important grassland areas such as the Sepik District.

Laboratory facilities are in the process of being established at Port Moresby, Lae and Keravat near Rabaul.

In conclusion, it can be said that this Territory, because of its great land area and wide range of environment, offers considerable scope for expansion of population and of productive effort for both export and subsistence crops. Many types of foods, both plant and animal, and other agricultural commodities such as rubber, fibres, medicinal substances and tobacco, are capable of production and there is room for expansion for all existing agricultural industries and the development of a number of new ones.

# NEW AND INTERESTING IDENTIFICATIONS.

## Plants.

### CLEMATIS GLYCINEIDES.

Evidence given in a murder case before the Supreme Court of the Territory revealed that the juice of green leaves of a plant later identified as **Clematis glycineides** was used by the native people to bring about abortion.

**Clematis glycineides** is popularly known as "Headache Vine" and is reputed to be poisonous to stock. Preliminary chemical tests have indicated that it probably contains Protoanomonol, a volatile toxic compound which quickly polymerises after steam distillation to the solid crystalline acid anemonin.

### PARSONSIA BURUENSIS.

The following is an extract from the report by the State Analyst, Brisbane, on a specimen of a vine identified as **Parsonsia buruensis**, the juice of which was responsible for the death of two native policemen.

There is no reference in the botanical literature to this particular species being poisonous, but several of the other species of Parsonsia are recorded as being toxic to stock. However, the Parsonsias belong to the family **Apocynaceae**, a family which contains many poisonous plants—Oleander, Strophanthus, etc.

Extracts of the bark and softwood portion of the vine gave negative tests for alkaloids, but when injected into guinea pigs proved very toxic, death resulting within ten minutes. A portion was submitted to the Physiology School, University of Queensland, for studies on the heart action of frogs. The resultant charts showed an action closely parallel to that of digitalis. It thus appears likely that the toxic principal of the vine is a cardiac glycoside.

The stomach of Kangelo, when opened, was empty, the inner surface being plum coloured. Extracts were made from this and from the stomach contents of Yamul, but when injected into guinea pigs were without toxic effects. In all probability, any glycoside originally present in the stomachs would have been decomposed.

## Insects.

### LEPIDOPTERA—Parasa lepida—Limacodidae.

(Nettle Caterpillar).

This insect generally attacks the lower fronds and damage is not as much as that caused by the Hopper-butterfly.

Two Plantation Directors, Mr. Fairfax-Ross from British New Guinea Company and Mr. A. Willis of Steamships Trading Company, reported serious attacks on 20 acres of coconuts at Hisiu Beach and in other scattered areas. Mr. A. Willis also reported attacks on plantations on the East Coast. As far as is known, this is the first recorded occurrence of this pest here.

Mr. Ross saw it attacking Breadfruits **(Artocarpus spp.)** in quantity, which coincides with the description of the host plant by Corbett (in his Bulletin—"Insects in Malaya").

The Caterpillar is greenish with redish stripes and with branched hairs. This insect is know also to attack Castor oil **(Ricinus communis)** and coffee **(Coffea spp.)**.

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